















# JOURNAL OF THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

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## 1.—MARINE COPEPODA FROM WESTERN AUSTRALIA.

### III.—LITTORAL HARPACTICIDS FROM PORT DENISON.

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Read 11th August, 1942.

The Copepods described below were taken from the reef fringing Leander Point, at the southern end of the bay at Port Denison (near Dongarra), in March 1940. The reef is part of the coastal limestone formation found along much of the south-western coast-line of Western Australia and is continuously submerged by from one to three feet of water. It supports a rich flora of small red and green algae among which live large numbers of copepods, mainly Harpacticoids.

Several new species and one new genus are described from this locality and the copepod fauna as a whole shows close affinity with those of the Mediterranean and Bermuda Is., as has already been shown for the more southerly regions of the Australian coast (Nicholls, 1941). Of particular interest in this connection is the occurrence of the genus *Cletopsyllus*, described from Bermuda by Willey and here represented by a second species, the description of which is based on a single ovigerous female as was also the case with Willey's species. This female was found, along with a *Nebalia*, in a discarded brown glass bottle lying on the surface of the reef, and a thorough search of the same area during March of the following year failed to locate any further specimens, from which it may be deduced that this is not a true dweller among algae but more probably lives in crevices in the reef and had entered the bottle at night, while swimming in the upper layers, and failed to find its way out through the narrow neck.

The following abbreviations have been used in the figures:—**a.1.**, **a.2.**, first and second antenna; **c.r.**, caudal rami; **g.a.**, genital area; **md.**, mandible; **mxl.**, maxillule; **mx.**, maxilla; **mxp.**, maxilliped; **p.1.-p.6.**, legs 1-6; **R.**, rostrum; **U.**, (**Ur.**), urosome.

Fam. **THALESTRIDAE** Sars, 1905.

Lang, 1936.

#### **Dactylopusia tisboides** (Claus).

*Dactylopus tisboides* Claus, 1863.

*Dactylopusia thisboides* (Claus) Sars, 1905, p. 126, pl. lxxvii, lxxviii.

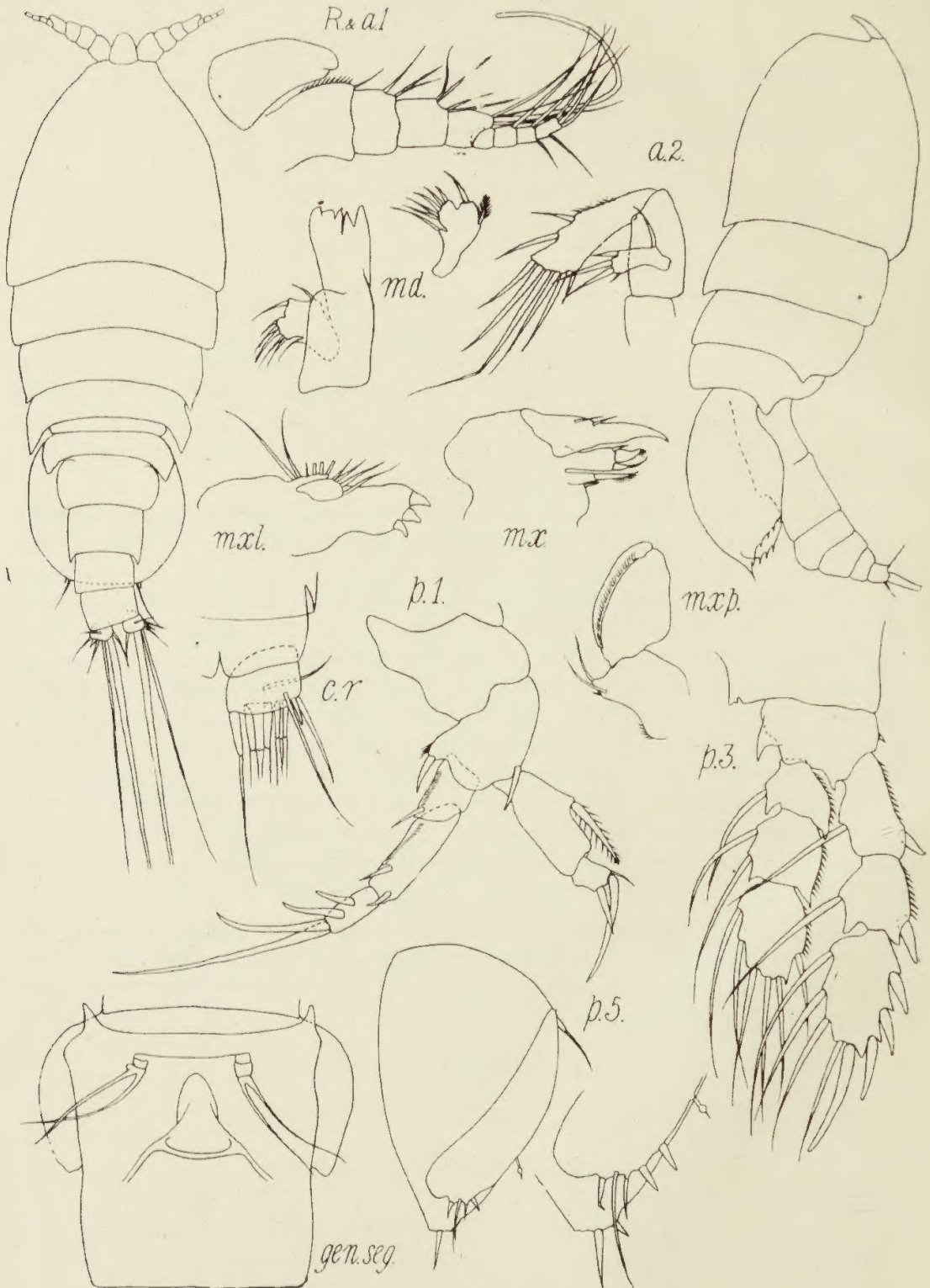
Occurrence: Ten females (five ovigerous), two juveniles.

Distribution: North Sea, North Atlantic, Mediterranean, Red Sea, Kerguelen.

***Neodactylopus cyclopoides* gen. et sp. nov.**

(Text fig. 1.)

This copepod is one of those Thalestrids related to *Eudactylopus*, from which it differs more particularly in the shape of the body and structure of the mouth parts. These differences are sufficiently marked to warrant the creation of a new genus. Since there is only the single species no generic diagnosis is given.



Text fig. 1. *Neodactylopus cyclopoides* gen. et sp. nov., female; whole animal  $\times 80$ , fifth leg  $\times 140$ , remainder  $\times 235$ .



Occurrence: A single female, with the remains of an egg-sac in the "brood-pouch."

Female: Length of anterior body 0.59 mm., of urosome 0.31 mm., total length 0.90 mm.; depth of body in head region 0.24 mm.; width in head region 0.31 mm., at genital segment 0.17 mm., at anal segment 0.09 mm.

Body wide anteriorly, tapering posteriorly; head fused with first segment; third and fourth segments with lateral upturned processes on their hinder margins; fifth segment very short, without lateral processes, narrower than genital segment which is partially divided and wider than long; the remaining three urosome segments are subequal in length and slightly wider than long; caudal rami short, wider than long, terminal setae almost as long as body. The rostrum is articulated with the head, rounded, and as long as the first segment of the antennule. The first antennae are 8-segmented, with 4 segments in the basal portion, which is twice as long as the distal part. The exopod of the second antenna appears to be 1-segmented, but this could not be made out clearly in the preparation; judging from the position of the proximal seta it is possible that this ramus is 2-segmented. The mandible has a strong biting edge and a 1-segmented palp; the maxillule is of similar appearance to the mandible, having a well developed gnathobase bearing three coarse teeth, and a small palp; the maxilla has a well developed terminal lobe and two inner lobes, strongly armed, with a rudiment of a third inner lobe; the maxilliped is very like that of *Eudactylopus*. The first legs differ from those of that species in that the endopod is shorter than the exopod, which has an enlarged middle segment; in its shape this endopod bears a certain resemblance to that of *Ialysus*. The swimming legs resemble those of other Thalestrids, particularly *Eudactylopus*, in which the seta formula is the same:

			endopod			exopod		
p. 2	..	..	1	2	221	1	1	223
p. 3	..	..	1	2	321	1	1	323
p. 4	..	..	1	1	221	1	1	323

and the setae are all finely plumose. The fifth legs are like those of *Eudactylopus*, and together with the broad genital segment serve as a brood-pouch for the protection of the egg-sac. The genital segment, which is divided only on the dorsal surface, bears lateral wing-like expansions dorsally on the anterior portion.

This copepod, which is undoubtedly a Thalestrid, resembles *Eudactylopus* in the enlarged fifth legs, structure of legs 2-4, and the first antennae, but differs in the mouth parts, first legs and shape of body. In the last feature it resembles *Dactylopodella* but differs from this genus in the reduced mouth parts and better developed swimming legs. (*See Addendum.*)

#### ***Parastenhelia forficula* (Claus).**

(Text fig. 2A.)

*Thalestris forficula* Claus, 1863.

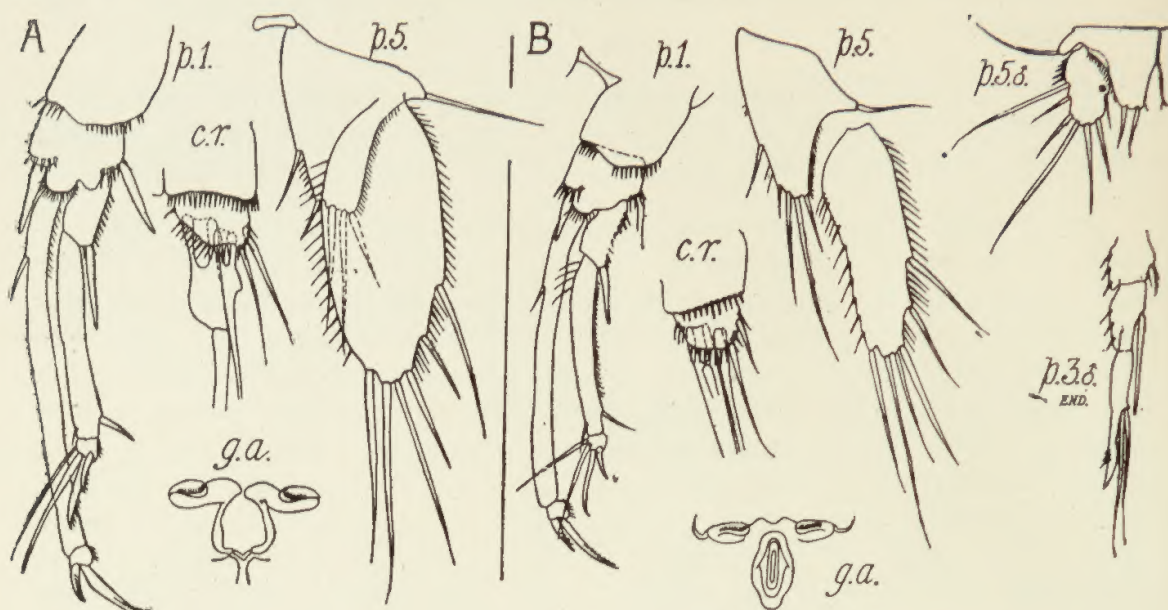
*Microthalestris forficula* (Claus) Sars, 1905, p. 123, pl. lxxvi.

*Parastenhelia forficula* (Claus) Lang, 1934, p. 22 et seq.

Occurrence: Three females (two ovigerous), 0.72 mm.

Distribution: Norway, British Isles, Woods Hole, Mediterranean.





Text fig. 2. A. *Parastenhelia forficula* (Claus), female; B. *P. forficula* (Claus) *littoralis* (Sars), male and female; all  $\times 200$ .

***Parastenhelia forficula* var. *littoralis* (Sars).**

(Text fig. 2B.)

*Thalestris forficula* Thomson, 1883.

*T. forficula* T. Scott, 1894.

*Microthalestris littoralis* Sars, 1911, p. 369, Supp. pl. 11, fig. 1.

*P. forficula* v| *littoralis* (Sars) Lang, 1934, p. 25, fig. 49-56.

Occurrence: Seven females (four ovigerous), 0.63—0.67 mm., one male, 0.54 mm.

Distribution: Mediterranean, Norway, Gulf of Guinea, New Zealand, Woods Hole, Bermuda.

Lang (loc. cit. and 1936, p. 52) shows that *Microthalestris* and *Parastenhelia* are synonymous, and further expresses the opinion that Sars' species *littoralis* is no more than a variety of *forficula* (Claus). He points out that the species is very variable and quotes Monard (1928, p. 348) to the same effect. In view of these opinions I have identified specimens found here with the species and its variety, and while there is little doubt about the identification of the variety, that of the former is open to question. The genital area of *littoralis* found here is very similar to the figure given by Lang (1934, fig. 51) though it does not show the full structure indicated by him. The first legs in both cases are much longer and more slender than has previously been described for either, and, in the case of the specimens identified as *forficula*, the genital area is of a quite different structure; the fifth legs also differ in that the end segment is ovate. It is possible that this represents a new species but for the present it is accepted as a variation. It should also be noted that the distal segment of the fifth leg of the male here identified as *littoralis* does not exhibit the segmentation shown both by Sars and by Lang, although the arrangement of the setae is the same.



Fam. **DIOSACCIDAE** Sars, 1906.

Nicholls, 1941a.

**Amphiascopsis hirsutus** (Thomp. & Scott).*Dactylop(h)usia hirsutus* Thompson & Scott, 1903, p. 269, pl. ix, fig. 19-24.*Amphiascopsis hirsutus* Nicholls, 1941a, p. 75.

This form has already been recorded from this coast (Nicholls, 1943) and was found here abundantly in both sexes and young stages, the adult size varying from 1.0 to 1.3 mm.

**Amphiascopsis tenuiculus** (Monard).*Amphiascus tenuiculus* Monard, 1928, p. 382, fig. xxix.*Amphiascopsis tenuiculus* Nicholls, 1941a, p. 75.

Two ovigerous females (0.50 mm.) of this form were found; it has previously been recorded only from Banyuls, on the Mediterranean coast of France. These specimens departed slightly from the description given by Monard, but I have little hesitation in identifying them with his species.

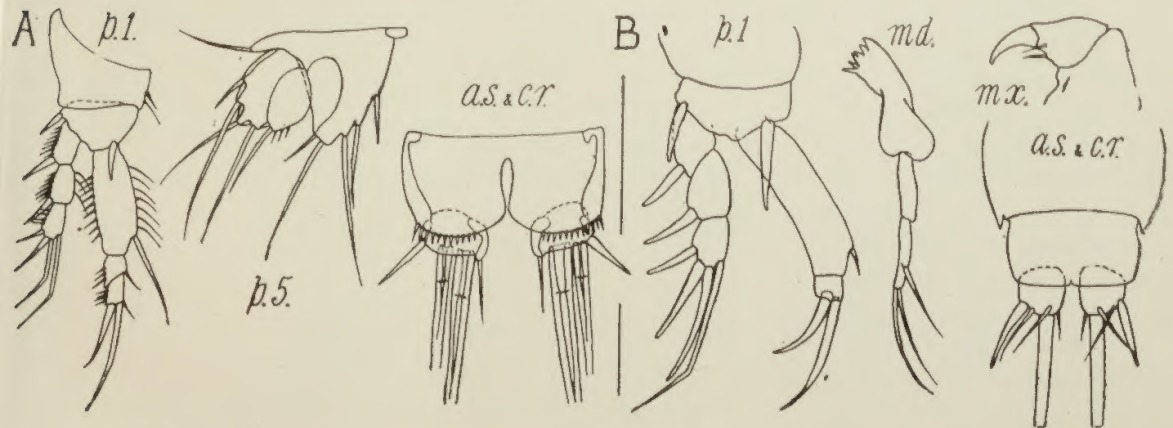
**Amphiascoides vararensis** (T. Scott).

(Text fig. 3A.)

*Amphiascus vararensis* T. Scott, 1903.*A. affinis* Sars, 1906, p. 168, pl. cix.*Amphiascoides vararensis* Nicholls 1941a, p. 81.

Occurrence: Seven ovigerous females, 0.67 mm.

Distribution: Scotland, Norway, Mediterranean.



Text fig. 3. A. *Amphiascoides vararensis* (T. Scott), female;  $\times 210$ ; B. *Parialysus robustus* (Nicholls), female; caudal remi  $\times 125$ ; others  $\times 210$ .

The specimens found here should almost certainly be identified with this species although there are small differences, chief of which is the proportions of the first leg, which resembles that of *hispidus*; the rostrum and fifth legs agree exactly with those of *vararensis*.

**Robertsonia paramonardi** sp. nov.

(Text fig. 4.)

Occurrence: Nine females (five ovigerous), two males.

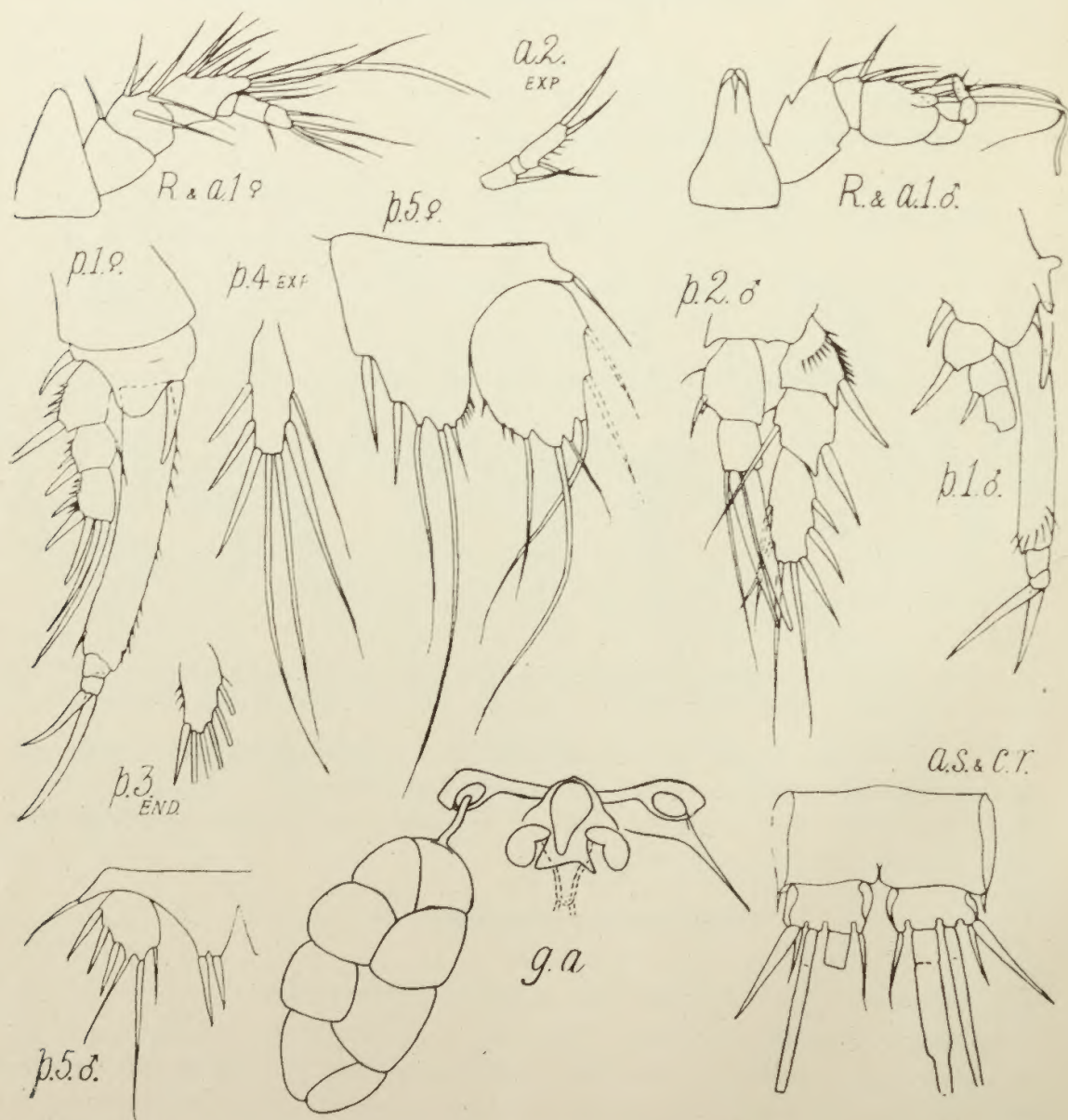
Female: Length 0.70 mm. This is a typical member of the genus as defined by me (1941a, p. 86) and approaches most closely to the species described by Klie (1937, p. 25) as *Varnaia monardi*. The first antenna is 6-segmented, with three in the basal portion; the rostrum is rounded and



unarmed. The second antenna has a 3-segmented exopod and the middle segment is without a seta; the remaining mouth parts are typical. The first legs resemble those of *monardi* but differ in the absence of the inner seta on the endopod, which is relatively longer when compared with the exopod than is the case in *monardi*; there is no break in the chitin on the inner margin to indicate that any of the fine hairs should be regarded as a small seta (cf. description of male). Legs 2-4 have the usual seta formula for the genus:

				endopod			exopod
p. 2.	..	..	1.	1.	121	0.	1. 223
p. 3.	..	..	1.	1.	321	0.	1. 123
p. 4.	..	..	1.	1.	221	0.	1. 223

and resemble those of *monardi* except that the third endopod clearly has three inner setae on the end segment, and the fourth exopod has the distal inner seta enlarged. The fifth legs are very like those of *monardi*. Two egg-sacs were present in all the ovigerous females. The genital area is similar to those of *tenuis* (Lang, 1935, fig. 5) and *monardi* (Klie, 1937, fig. 53)



Text fig. 4. *Robertsonia paramonardi* sp. nov., male and female;  $\times 300$ .



Male: Length 0.56 mm. The first antenna is 6-segmented as in the female; the rostrum tapers more than that of the female, is rounded, and shows a marginal chitinous thickening similar to that shown for *monardi*. The first legs in the specimen figured lacked the inner seta on the endopod and the inner seta on the middle segment of the exopod, but this leg was damaged during dissection and both of these setae were found on the second specimen, exactly as described and figured for *monardi* by Klie (op. cit., fig. 67). The armature of the swimming legs is like that of the female except for the modified second endopod, which is 2-segmented, the distal segment armed with two equal terminal spines and a seta, as in *monardi*. The fifth legs are like those of *monardi*.

Lang (1935, p. 4) refers to his inability to find any specimens of *Robertsonia tenuis* with egg-sacs, but Klie (op. cit., pp. 25, 28) found these paired in *monardi*, as is also the case with the present species. Except for a few minor points the male of this species cannot be distinguished from that of Klie's species. Klie's material was taken from the brackish water of the Varna Estuary whereas this material is truly marine. The genus is typically euryhaline.

**Parialysus robustus** (Nicholls).

(Text fig. 3B.)

*Tydemanella robusta* Nicholls, 1941, p. 416, fig. 19.

*Parialysus robusta* Nicholls, 1941a, p. 91.

Occurrence: One ovigerous female, 1.1 mm.

Distribution: Sellick Beach and Spencer Gulf, South Australia.

This copepod, originally assigned to the genus *Tydemanella* was later transferred to a new genus for the reasons set out on page 90 (Nicholls, 1941a). Slight differences from the original description were observed and are shown in the accompanying figure, which includes a drawing of the maxilla, previously unobserved. The differences are an extra spine on the end segment of the first exopod, the arrangement of setae on the mandible palp, and additional small setae on the caudal rami. The maxilla is without secondary lobes. With reference to the footnote (Nicholls 1941, p. 418) it can here be stated that the middle segment of the second endopod has only one inner seta as figured. (See Addendum.)

Fam. **LAOPHONTIDAE** T. Scott, 1905.

Sars, 1907.

Nicholls, 1941a.

**Laophonte (Laophonte) cornuta** Philippi.

*L. cornuta* Philippi, 1840.

*L. cornuta* Sars, 1907, p. 235, pl. clvii, clviii.

*L. (L.) cornuta* Nicholls, 1941a, p. 99.

Occurrence: One female (0.91 mm.), two males (0.74 mm.), one immature female (0.70 m.m.).

This species is of world-wide distribution and it is not surprising to find it on this coast. It has already been recorded from South Australia (Nicholls, 1941).

**Laophonte (Laophonte) adduensis** Sewell, 1940.

(Text fig. 5.)

Occurrence: Two females, one male.

Female: Length 1.1 mm. The body bears a strong resemblance to that of *cornuta*, except that there are two dorsal grooves in the head, the posterior median spine on the anal segment is less pronounced, the caudal rami are longer and more slender, and the fifth legs are relatively longer, extending back to the anterior margin of the pre-anal segment. The first antennae are 4-segmented and slender, the spur on the first segment is short and the second segment is without a spur. The second antennae have a small



Text fig. 5. *Laophonte (L.) adduensis* Sewell, male and female; whole animal  $\times 75$ , rest of female and antennule of male  $\times 160$ , rest of male  $\times 270$ .



one-segmented exopod, bearing two terminal setae. The mouth parts are typical. The first legs are like those of *cornuta* but are more slender, and the seta formula for legs 2-4 differs from that of *cornuta* in the second exopod.

			endopod			exopod	
p. 2.	..	..	1.	220	0.	1.	122
p. 3.	..	..	1.	321	0.	1.	223
p. 4.	..	..	1.	221	0.	1.	223

Here the second exopod has only two outer spines on the end segment. The fifth legs bear a very strong resemblance to those of *cornuta*, but are relatively longer and more slender; the number and arrangement of the setae on these legs are also similar, but they are much shorter. The caudal rami are relatively longer and more slender, being twice as long as the anal segment, but are widened basally so that they do not appear to be widely separated as they are in the type species. The armature is very similar but one of the small distal setae is absent.

**Male:** Length 0.93 mm. The body resembles that of the female; the rostrum is very small and fused with the head. The first antennae are 6-segmented, the first segment bears a small spur while there is none on the second, the fourth segment is only slightly swollen and bears a long, strong spine on the anterior margin; in *cornuta* this segment is greatly enlarged and there is a relatively short spur in place of the spine. The exopod of the second antenna bears two long subequal setae and a short one terminally, and one lateral seta. The swimming legs are like those of the female except for the endopod of the third leg. This is 3-segmented, the middle segment is prolonged in the form of a spine, as in *cornuta*, but the shape of this spine is markedly different from that of the type. The fifth legs again are more slender and the basal expansion is well developed, extending to a little more than half way along the distal segment; the latter bears an inner seta not found in *cornuta*.

This species clearly belongs to the *cornuta*-group (Nicholls, 1941a) and is closely related to the type species, particularly in the structure of the fifth legs of the female. It differs from the other members of this group in several respects, notably in the seta formula and in the shape of the fifth leg. In general the male resembles those of *cornuta* and *hirsuta*; the projection on the middle segment of the third endopod is simple in *cornuta* and truncate in *hirsuta*, in this species it is specially modified; in both *cornuta* and *hirsuta* the fifth leg is without a basal expansion, which is well developed here; the fourth segment of the first antenna is smaller in this species than in either of the others and has a relatively long spine in place of the spur. (See Addendum.)

#### **Laophonte (Laophonte) congenera Sars.**

(Text fig. 6B.)

*L. congenera* Sars, 1908, p. 257, pl. clxxvii.

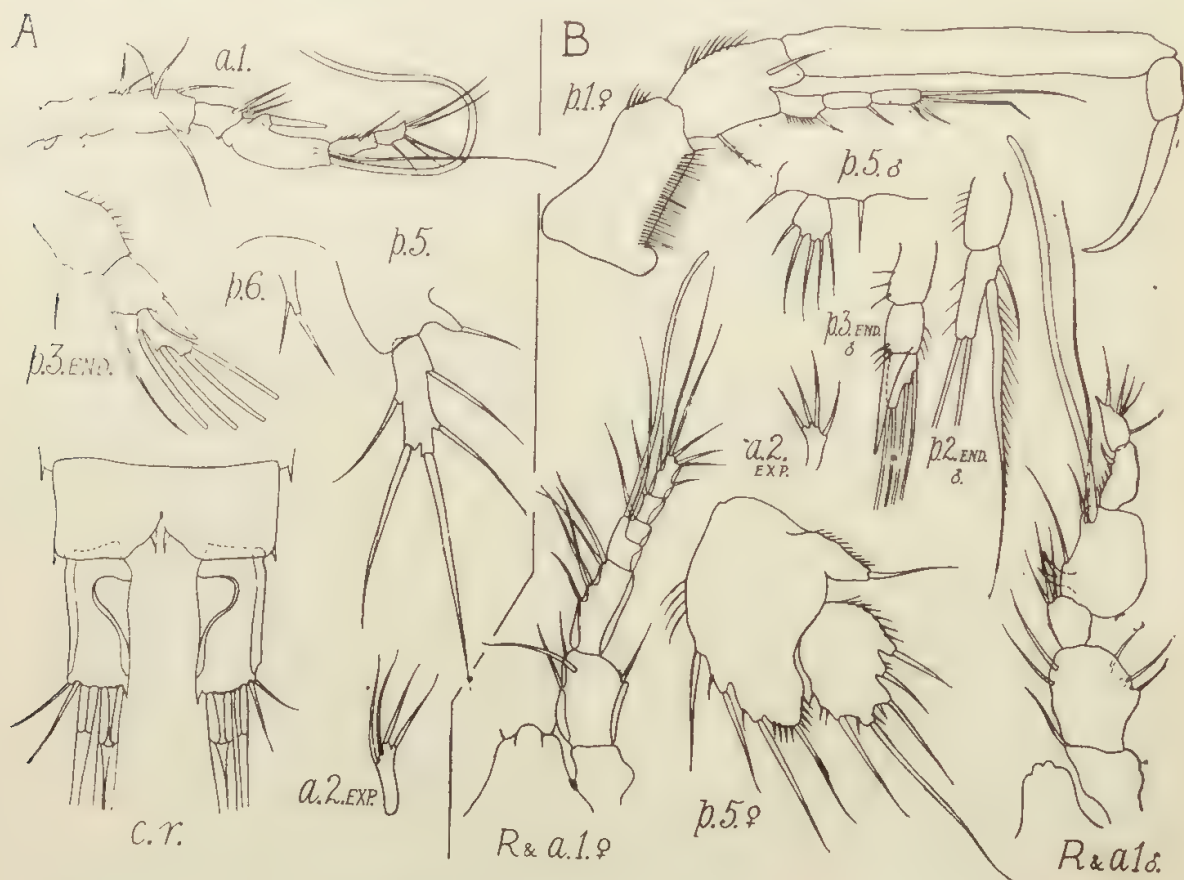
*L. (L.) congenera* Nicholls, 1941a, p. 99.

Occurrence: Ten females (three ovigerous) 0.50–0.56 mm.; one male, 0.50 mm.

Distribution: Norway, Mediterranean, Bermuda.

This species closely resembles *brevirostris* (Claus) as pointed out by Willey (1935, p. 76). He finds that the segmentation of the first antenna is the only tangible difference, and that the rostral condition described by Sars for *congenera* was associated with those specimens which he identified as *brevirostris*. In the material taken here the female has the rostrum with an entire margin and a first antenna which is clearly 7-segmented, while the male has a bilobed tip to the rostrum and a 6-segmented antenna. As was found also by Willey the male fifth leg has only a single seta representing the basal expansion.

In the female there is no trace of a spur on the second segment of the antenna whereas this is small but clearly defined in the male. Other male characters are clearly those of *congenera* rather than *brevirostris*, particularly the position of the inner seta on the second endopod. The caudal rami in both sexes are distinctly shorter than the anal segment; in both *brevirostris* as described by Sars and *congenera* there is little difference in the relative lengths of these parts.



Text fig. 6. A. *Laophonte rhodiaca* Brian, male; antennule  $\times 250$ , other parts  $\times 345$ . B. *Laophonte* (L.) *congenera* Sars, male and female; all  $\times 345$ .

### *Laophonte rhodiaca* Brian.

(Text fig. 6A.)

*L. rhodiaca* Brian, 1928.

Occurrence: One immature female, 0.54 mm.; one male 0.46 mm.

Distribution: Mediterranean.

In an earlier paper (1941, p. 423) I suggested that this species, known only from the male, might in reality be synonymous with *bulbifera* Norman, of which only the female has been described. *L. bulbifera* has not yet been



recorded from this region, but the male taken in this collection can clearly be identified with Brian's species. It is unfortunate that the female taken with this male was immature, so that this question is still open.

***Echinolaophonte armiger* (Gurney).**

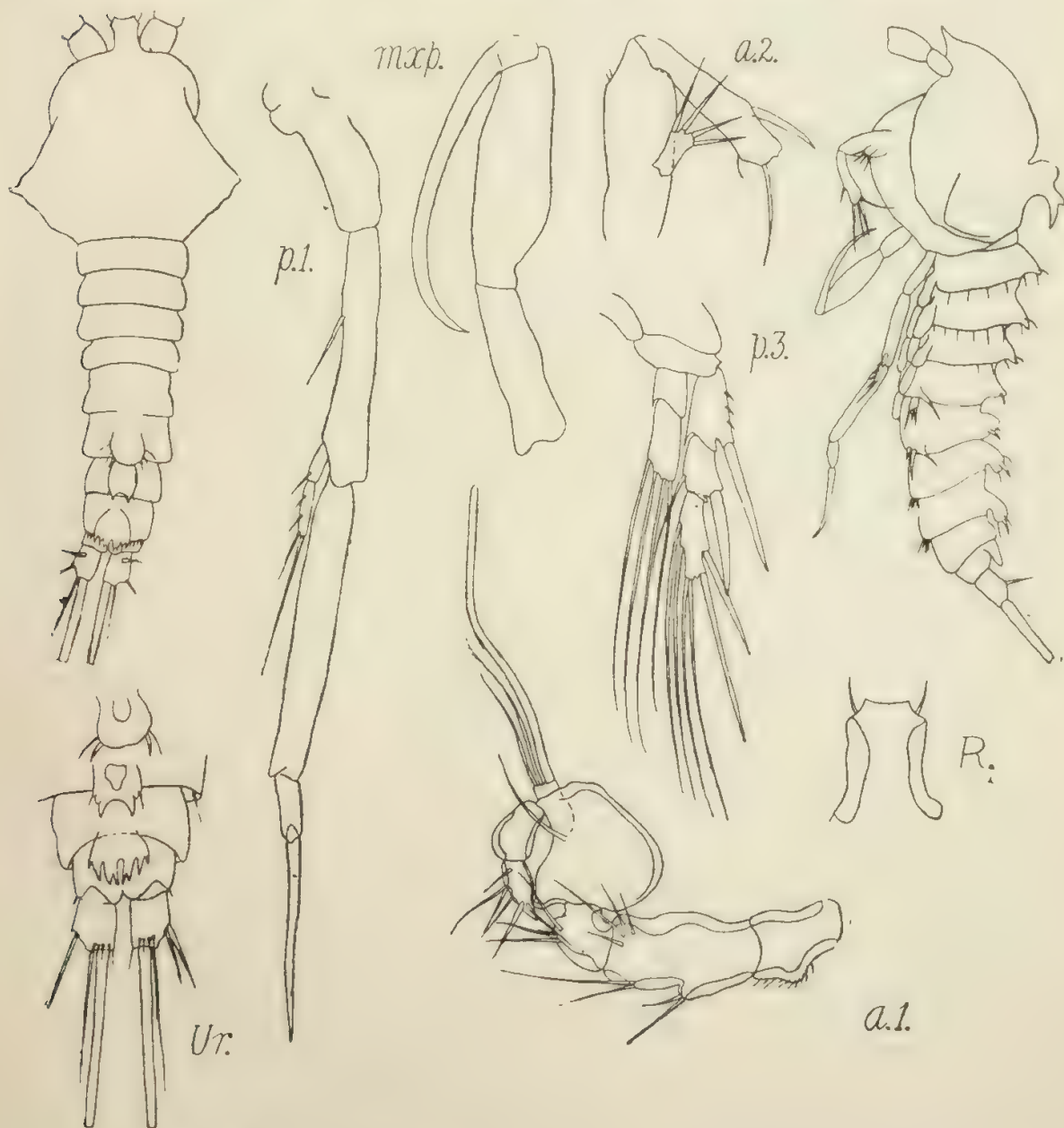
(Text fig. 7.)

*Laophonte armiger* Gurney, 1927, p. 554, fig. 159.

*E. armiger* Nicholls, 1941a, p. 95.

Occurrence: One male, 0.46 mm.

Distribution: Gulf of Suez, Suez Canal, Mediterranean, Bermuda.



Text fig. 7. *Echinolaophonte armiger* (Gurney), male; whole animal  $\times 140$ , urosome  $\times 230$ , appendages  $\times 385$ .

The male of this species has been described by Brian (1928, *hystrix*) and by Willey (1930). The specimen found here differs in a few minor points, in particular the narrower rostrum, the shape of the third endopod and, to a certain extent, in the dorsal body spines. The first antennae differ from Willey's description but in the single specimen available to me this

appendage was closely folded so that it was difficult to make out the structure of the terminal part clearly; the basal part agrees with Willey's figure. Until the female is found it is difficult to be certain that this is correctly identified, but in view of the close relationship already established between the Mediterranean, Bermudan and Australian regions, it is at least probable that it is the same species.

Fam. **NORMANELLIDAE** nov.

The question whether *Normanella* should be included in the Laophontidae has already been discussed (Nicholls, 1941a, pp. 92-93). It was concluded that this genus departs in every important feature from typical members of that family, and it was, therefore, temporarily removed to the Canthocamptidae. A review (as yet unpublished) of the genera hitherto included in the latter indicates equally clearly that it cannot remain there. The only remaining course is to create a new family for its reception.

Willey (1935, p. 72) has pointed out a certain resemblance between his genus *Cletopsyllus* and *Normanella*, and I find that these two genera together constitute a well defined family, with the following diagnosis:

Body tapering, more or less deeply constricted intersegmentally; rostrum triangular or truncate, broad at the base, articulated; first antenna 4- to 7-segmented, with three segments in the basal portion; second antenna with the basal segment undivided, exopod 1-segmented or absent; mandible palp biramous, each ramus 1-segmented, the proximal ramus may be reduced to a seta; maxillule with exopodal lobe; maxilla with three inner lobes of which the proximal may be reduced to a seta; maxilliped 3-segmented, prehensile. Legs with 2-segmented endopods and 3-segmented exopods; first leg with the exopod shorter than the basal segment of the endopod and with an inner seta on the middle segment, endopod with a spine and a geniculate seta terminally; fifth legs 2-segmented, both segments usually elongate; caudal rami slender and widely separated. Male with first antenna *chirocerate* (Lang, 1935) and legs unmodified.

The two genera are distinguished by the presence of postero-lateral processes on the urosome segments in *Cletopsyllus*, not found in *Normanella*.

**Cletopsyllus secundus** sp. nov.

(Text fig. 8.)

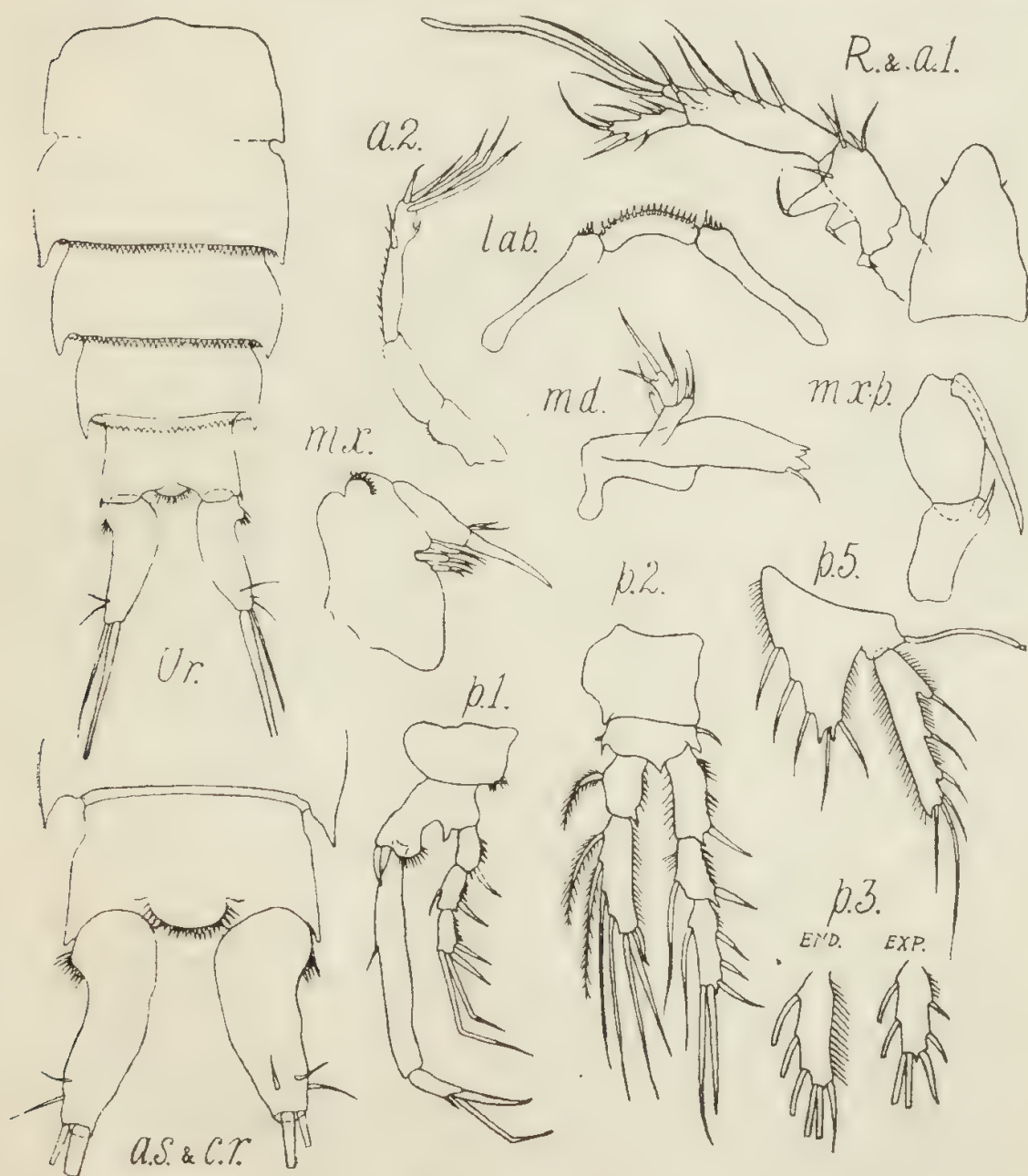
Occurrence: A single ovigerous female, found in a dark brown glass bottle lying on the surface of the reef.

Female: Length 0.98 mm. The body was so strongly flexed that it was necessary to divide it between the metasome and urosome in order to measure it, and no drawing of the whole animal was made. The greatest width was 0.24 mm. The metasome is of equal width throughout and the urosome at the genital segment is as wide as the metasome, gradually tapering to a width of 0.15 mm. at the anal segment. The posterior region of the urosome showed intersegmental constriction, whereas the outline of the metasome was entire. The whole body was thickly encrusted with epizoots and detritus.

The rostrum is prominent, rounded, armed with small lateral setae. The first antenna is 4-segmented, the three basal segments well developed and bearing spiny or nodular outgrowths; the distal segments are fused into



one short segment and the whole appendage is very similar to that of the type species, *C. papillifer* Willey (1935, p. 70, fig. 75-85). The second antenna has the basal segment partially divided and is without an exopod. The mandible palp is biramous, the outer ramus rudimentary. The maxillules were both overlain by the maxillae in the preparation and were thus difficult to make out. The latter are stoutly constructed, with a well developed terminal lobe and three small inner lobes. The maxilliped shows no unusual



Text fig. 8. *Cletopsyllus secundus* sp. nov., female; urosome, in ventral view,  $\times 100$ , antennae, legs and caudal rami  $\times 185$ , mouth parts  $\times 305$ .

feature. The swimming legs are slender and hirsute. The endopods are 2-segmented and the exopods 3-segmented in each leg; the basal segment of the endopod of the first leg is elongate, the whole ramus about twice as long as the exopod, and bears an inner seta slightly proximal to the middle; the end segment bears terminally a curved spine, a long geniculate seta and a small seta.

The seta formula for legs 2-4 is:

			endopod	exopod
p. 2.	..	..	1. 421	0. 1. 123
p. 3.	..	..	1. 321	1. 1. 223
p. 4.	..	..	1. 321	1. 1. 223

The fifth legs have a conical basal expansion, bearing five setae and an elongate distal segment with six setae. The caudal rami are widely separated and outwardly curved, and bear terminally one long seta, as long as the urosome, and one shorter seta, and three short setae distally. The structure of the genital area could not be made out.

This species differs from Willey's in the shape of the rostrum, which is much more slender and rounded, whereas in *papillifer* it is bifid; the third segment of the first antenna has only four outer setae and a smooth inner margin; the basal segment of the second antenna is partially divided, there is no exopod and the whole appendage is more slender; the mandible palp is biramous, whereas in *papillifer* it is described as uniramous, though in fig. 78 there appears to be a very rudimentary exopod; in the first endopod the inner seta is proximal to the middle of the segment and the distal segment lacks the lateral setae found in *papillifer*; the end segment of the fourth exopod has only two inner setae, like that of the third leg; in the fifth leg the basal expansion is larger, reaching to the middle of the distal segment and bears two short terminal spurs; the caudal rami are not hirsute marginally except for the tuft of hairs on the basal projection and the anal segment is only slightly produced at the point of articulation of the caudal rami; lastly the urosome segments are without the prominent lateral expansions found in *papillifer*.

The occurrence of a second species of the genus in this region is a further link between the fauna of Bermuda and that of the Australian region.

It is unfortunate that the males of this genus are as yet unknown.

Fam. **CEYLONIELLIDAE** A. Scott.

**Ceyloniella armata** (Claus).

*Jurinia armata* Claus, 1863.

*C. armata* Willey, 1930, p. 111.

Occurrence: Two females (one ovigerous) 0.93 mm.

Distribution: Mediterranean, Suez Canal, Ceylon, Malay Archipelago, South Australia.

Fam. **METIDAE** Sars.

**Metis jousseaumei** (Richard).

*Ilyopsyllus jousseaumei* Richard, 1892.

Occurrence: Many specimens in all stages of development.

This copepod has already been recorded from this coast (Nicholls, 1941b, 1943).



There occurred in this collection in addition to those copepods described above a species of *Harpacticus* and one of *Tisbe*, both probably new. The descriptions of these are withheld until conditions for obtaining certain literature have improved. The males of two different species of *Laophonte* were also found, and these await the discovery of their respective females. They were not identifiable with any of the known males.

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#### ADDENDUM.

Since this account was sent to press I have seen Sewell's work on the Harpacticoids of the John Murray Expedition (Vol. VII (2), pp. 117-382, British Museum (N.H.), London, 1940). In this (p. 219) he described a species "*Eudactylopus anomala*" from the male only. Comparison shows that this is undoubtedly a member of the new genus, *Neodactylopus*, described above. That *E. anomala* is probably not the male of *N. cyclopoides* is suggested by the structure of the first legs which, though similar in general, differ in important detail. This and the exopod of the second antenna are the only points of difference, excluding sexual differences, that can be made out.

On pages 229-236 Sewell described two new species of *Ialysus*. The second of these, *I. proximus*, at first sight would appear to be congeneric with *Parialysus*. The chief objection to accepting complete identity between his *Ialysus* species and *Parialysus* lies in the apparent difference in the seta formula. That given by Sewell (p. 232) compared with that given by me (1941, p. 418) for *Parialysus* shows his second leg identical with my third; his third with my fourth; and his fourth with my second.

On pages 314-317 Sewell described *Laophonte adduensis* from the Maldivic Archipelago. It is clear that the species found here and described above is identical with that described by Sewell, who had only females at his disposal. Both sexes were found here.

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## 2—MARINE COPEPODA FROM WESTERN AUSTRALIA

### IV.—PSAMMOPHILOUS HARPACTICIDS.

By A. G. NICHOLLS, Ph.D., University of Western Australia.

Read: 13th October, 1942.

Sand inhabiting copepods are probably to be found in beaches all over the world but owing to their very specialized habitat it has been suggested that each species tends to have a very limited distribution, so that adjacent beaches might harbour entirely distinct species (Wilson, 1932, pp. 6-7; 1935). While this is true up to a point, later work has shown that not all such species are so restricted in their distribution. Kunz (1937, 1938) has recorded from Kiel Bay species which were originally described from Great Britain (*e.g.*, various species of *Paramesochra* and *Stenocaris minuta* Nicholls, 1935) and similarly *Remaneia arenicola*, first described by Klie (1929) from Kiel Bay, has since been recorded from the Firth of Clyde (Nicholls, 1939).

The occurrence of such copepods in the sand beaches of Australia is not surprising, and in this paper three such copepods are described, each of them requiring a new genus for its reception. Samples were collected from two localities some 300 miles apart; the first, in October, 1939, at Leighton Beach in the neighbourhood of Perth, and the second in March, 1940, at what is known locally as the "Back beach" at Dongarra. The first tentative search for sand-dwelling copepods in the local beaches failed, since previous experience had shown that they were most abundant within the top 10 cms. of sand. The coast line of Western Australia is, except in a few places, exposed to the force of westerly gales from the Indian Ocean, so that the upper layers are liable to be continuously turned over by wave action and disturbed. It was not until the top six inches of sand was thrown aside and sand from below that level washed for copepods that any were found, and even then not in any great abundance. It is of interest to note that the two species obtained in the region of Perth occurred also in the samples taken at Dongarra, 300 miles to the north.

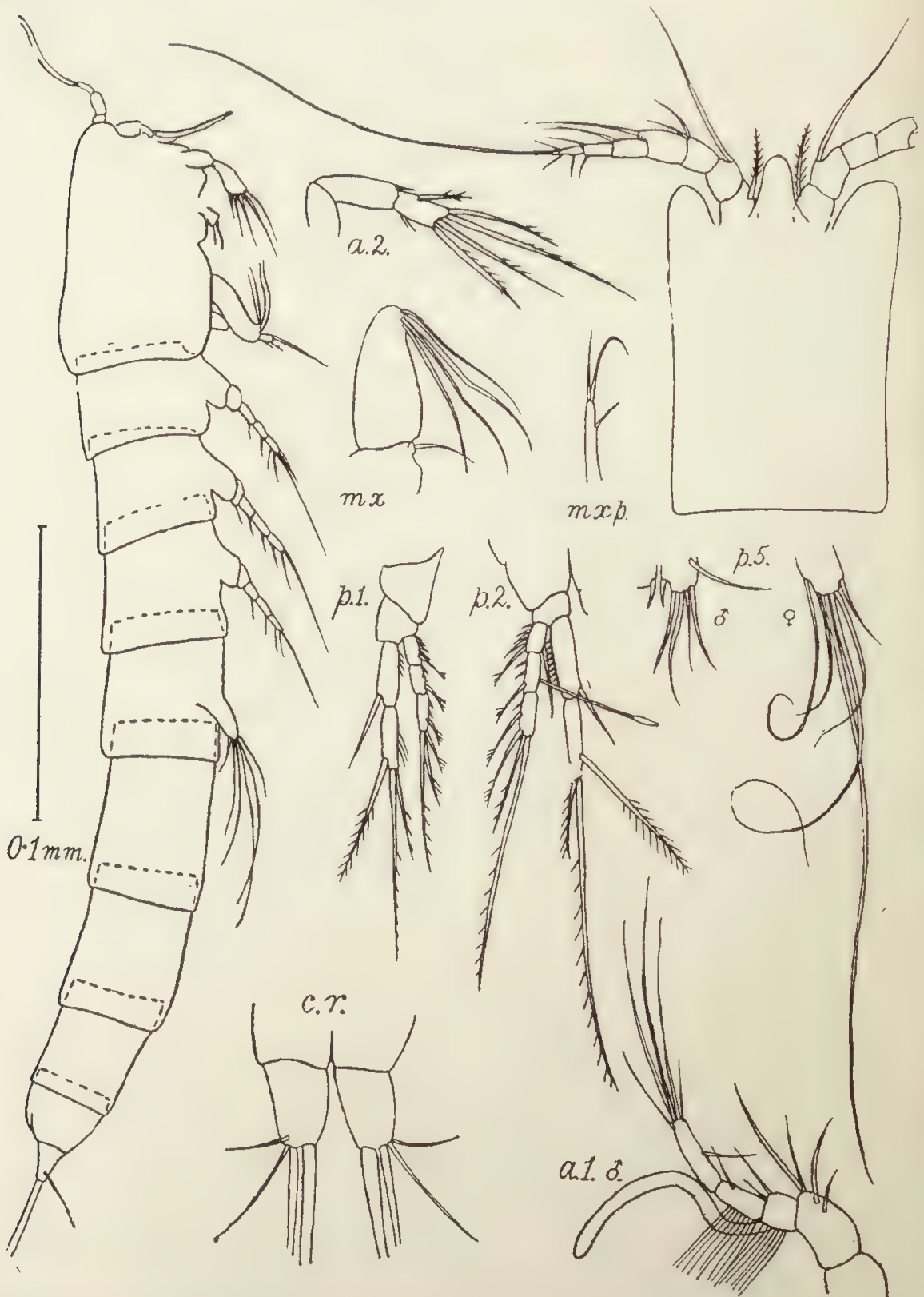
The species found here are related to those of similar habitat from European and American shores. One is an Ectinosomid, the other two are typical of certain groups of Canthocamptids.

In making preparations of such small copepods (all of these are under half a millimetre) there is a loss in definition owing to the clearing effect of Monk's (1938) medium, which is otherwise very suitable, and the appendage absorbs a very small quantity of the picro-indigo-carmin stain, so that permanent preparations made by this method are not the most satisfactory for detailed examination.

The procedure adopted here has been to remove and mount each appendage in a small quantity of stain for making the drawings and then to transfer the appendage to another slide for permanent mounting. Thus details can be obtained which might otherwise be overlooked. The mouth parts, of course,

are too small to be recovered after dissection and so the head is stained as a whole and dissected in Monk's medium, or may be examined from a second specimen by dissection and mounting in stain, or in formalin, and then discarded after drawing.

An explanation of the letters used in the figures has been given in Part III. of this series (this Journal, Vol. XXIX., p. 1).



Text fig. 1.—*Ectinosomoides longipes* gen. et sp. nov. ; whole animal  $\times 360$ , other figures  $\times 600$ .



It is a pleasure once more to acknowledge, with gratitude, the grant made by the Trustees of the Science and Industry Endowment Fund enabling me to purchase a dissecting microscope which made possible the study of these copepods.

Fam. **ECTINOSOMIDAE.**

Sars, 1911, p. 28.

This family is comprised of bottom living forms, usually inhabiting mud or sand, but includes also the free swimming *Microsetella*. It is one of the characteristics of the family, and more particularly of the genus *Ectinosoma*, that the body is "pronouncedly fusiform" and that the "cephalic segment is gradually attenuated in front" (Sars, 1911, p. 29). Furthermore, the fifth leg consists of "two well defined joints" and the distal joint is trilobate.

Now the sand-dwellers *Arenosetella* and *Hastigerella* depart noticeably from typical Ectinosomids in these features. In both genera the head is rectangular, without any anterior attenuation, and the fifth legs have both segments partially or completely fused while the trilobate condition of the distal segment has been lost.

It is for these reasons that I cannot agree with Kunz (1937, p. 100), who suggests that *Hastigerella* appears to be an aberrant *Ectinosoma*. It is much more closely related to *Arenosetella* than to *Ectinosoma* and but for the lack of the claw-like structure on the dorsal surface of the anal segment of the former could well be identified with that genus, in particular with *A. germanica* Kunz (1937, p. 95) which, in my opinion, is closer to *Hastigerella* than to Wilson's *Arenosetella*.

Similarly, I am inclined to think that *Ectinosoma leptoderma* and *E. tenuissima* Klie (1929) should not be identified with that genus since both have the rectangular head. One, however, has the fifth leg with both segments well-defined although the distal segment is not shown as trilobed, and both appear to lack the long inner modified setae on the endopods of the legs which were described for *H. palpilabra* and for *A. germanica* but were not present in *A. spinicauda* and *A. fissilis*.

Into which, if either, of these genera Klie's species should go or whether they constitute a new genus does not at present concern me, but I am of the opinion that they are not true *Ectinosoma* species.

***Ectinosomoides longipes* gen. et sp. nov.**

Occurrence. Back beach, Dongarra, March, 1940, in sand washings from below six inches; both sexes taken but not abundantly.

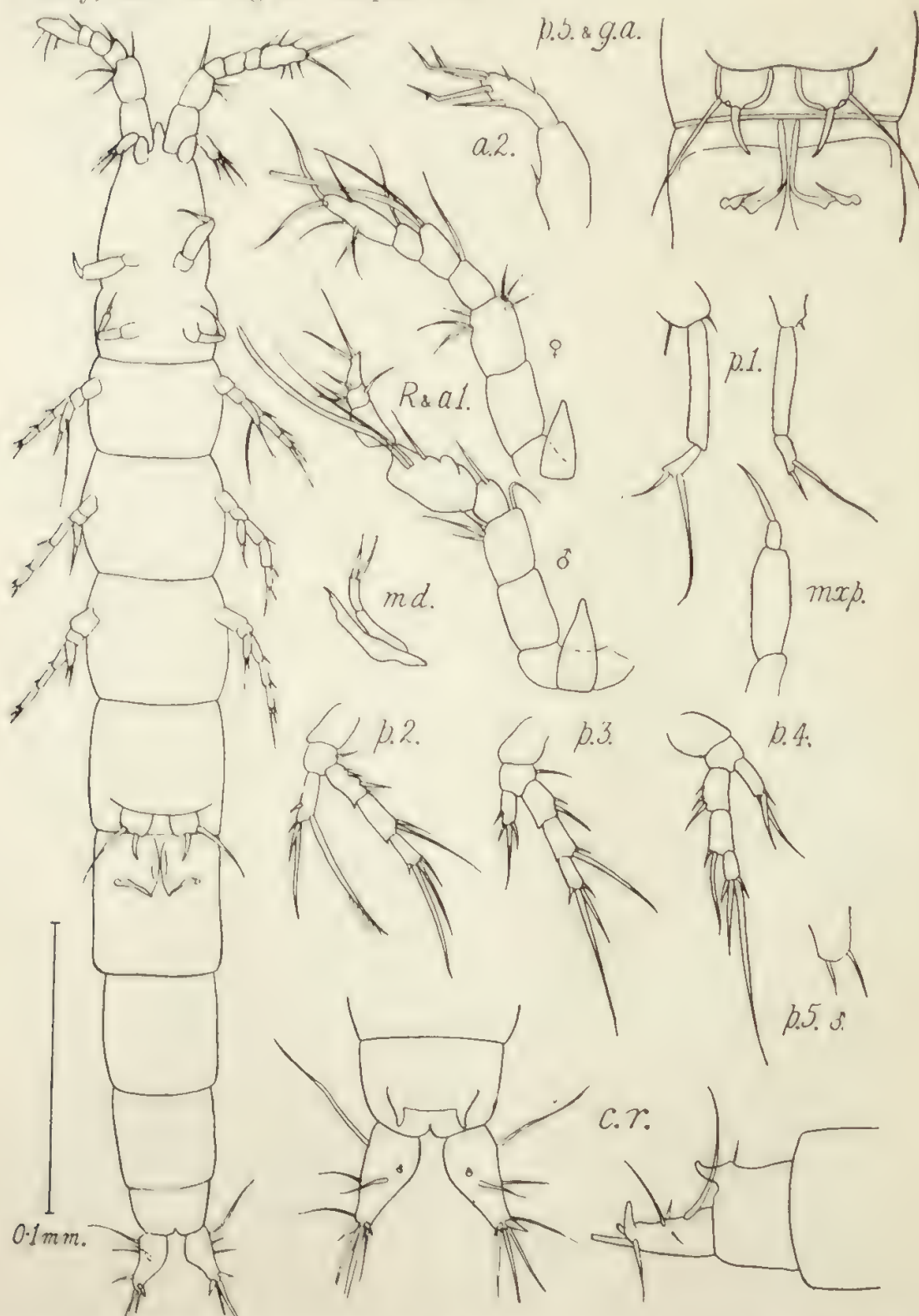
Female. Length 0.36 mm. Body long and slender, widest in front, tapering very slightly posteriorly. Head rectangular in dorsal view, genital segment undivided, caudal rami tapering, with two unequal setae, the longer almost as long as the whole body. Rostrum prominent, rounded, fused with the head; first antenna seven-segmented; second antenna without exopod; mouth parts much as in *Hastigerella* (Nicholls, 1935) except maxilliped, in which the terminal portion bears a lateral seta in addition to the two terminal setae.

Legs 1-4 with exopods three-segmented, their outer margins densely spinous; middle segment bearing a long inner modified seta in legs 2-4; endopods two-segmented and longer than the exopods.

## Seta formula.

			endopod	exopod
p. 1	....	....	1. 120	0. 0. 022.
p. 2-4	....	....	1. 120	1. 1. 022.

Fifth legs composed of simple elongate lamellae, adjacent in mid-line of body, each bearing six unequal setae.



Text fig. 2.—*Psammopsyllus operculatus* gen. et sp. nov.; whole animal  $\times 360$ , other figures  $\times 600$ .



Male. Length 0.34 mm. Body and most appendages similar to those of the female. Urosome five-segmented: first antennae probably seven-segmented, but the segmentation was not distinct in my preparation: the fourth segment bears a long stout sensory filament and there is probably a more slender one terminally. Fifth legs smaller than those of the female and the setae much shorter, the innermost being altered into a small spine.

Like *Pseudectinosoma* (Kunz, 1935), this copepod differs from other members of the family in the possession of two-segmented endopods in all the swimming legs. This condition in the first legs is known for two genera, *Halophytophilus* Brian (1918) and *Bradollopsis* Brian (1924) *vide* Lang, 1935, p. 335. It further differs from *Ectinosoma* in the shape of the body and structure of the fifth legs, and from *Arenosetella* in the absence of the anal appendages. It differs from *Hastigerella* most noticeably in the condition of the endopods, and absence of exopod on the second antenna, while the mouth parts appear to be more reduced. *Pseudectinosoma* has the typical fusiform body and shows a number of differences in the proportions and armature of the swimming legs. The second antenna and fifth legs are less reduced.

Fam. STENOCARIDAE sens. str.

Lang, 1936.

*Psammopsyllus operculatus* gen. et sp. nov.

Occurrence. Leighton Beach, and Back Beach, Dongarra: washed from sand below six inches from surface: both sexes, moderately abundant.

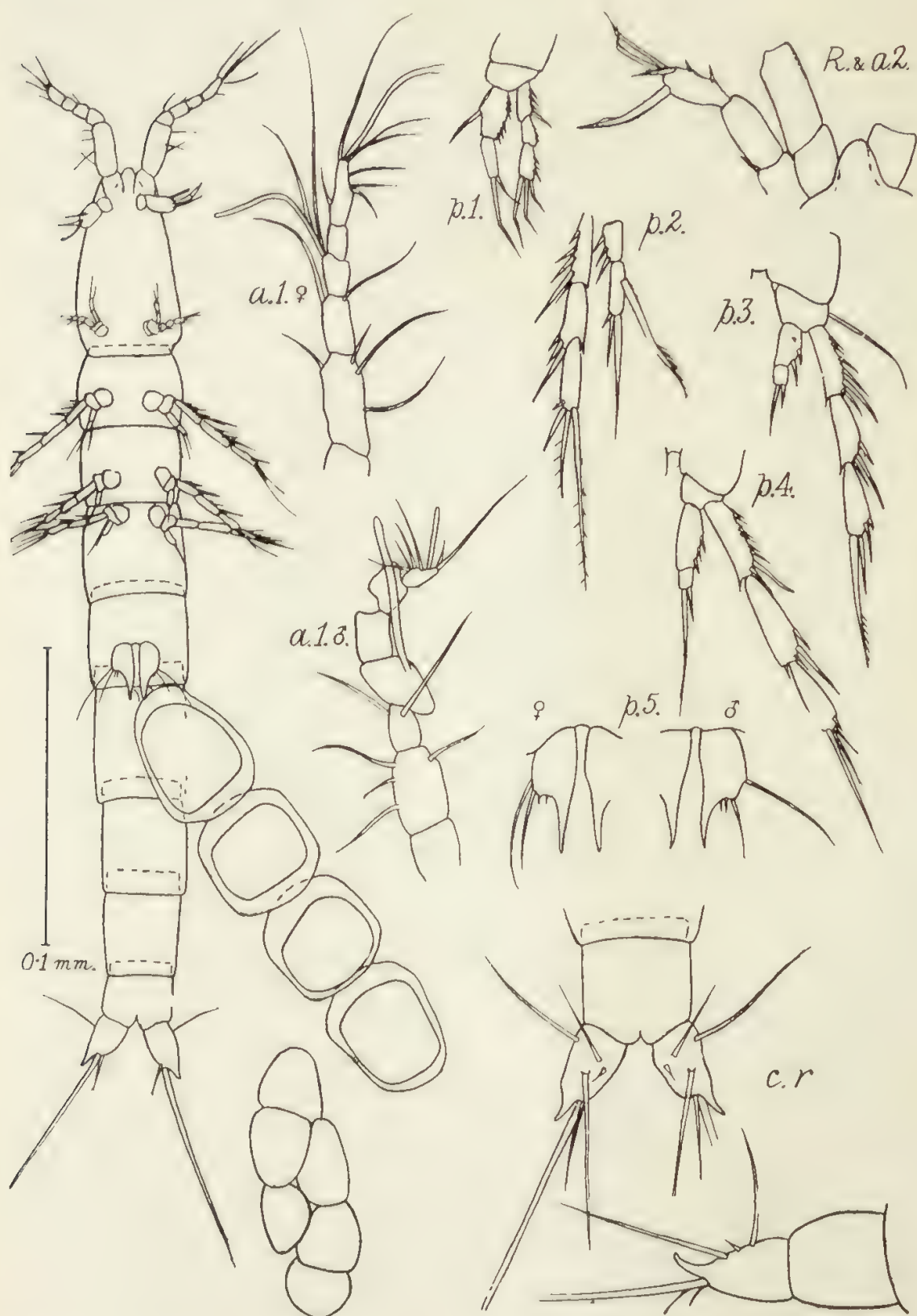
Female. Length 0.39-0.45 mm. Body elongate, cylindrical, widest in middle, tapering slightly towards each end. Head fused with first segment and line of fusion indicated by a constriction. Head widens posteriorly, and the rostrum is prominent, pointed, and articulated with the head. First antenna six-segmented, geniculate between second and third segments, and with a short sensory filament attached distally to the fourth segment. The end segment appears to be composed of three segments fused into one. Second antenna with exopod replaced by a seta. Mandible with long slender gnathobase and two-segmented palp. The maxillule was not seen and the maxilla was overlain by the maxilliped so that it was not sufficiently distinct to figure, but it appears to have at least two accessory lobes. Maxilliped moderately strong, with a single, short, terminal claw.

The swimming legs are carried attached to the ventro-lateral portion of the segments so that they tend to project ear-like from the body, and provide a wide ventral space between each member of a pair. The first leg has a long, slender, two-segmented endopod, the basal segment six to eight times as long as wide and three times as long as the distal segment which bears two unequal strong terminal claws. The exopod is absent or may be represented by a minute knob bearing a tiny seta, or by a seta alone.

Legs 2-4 have three-segmented exopods in which the segments are short and stout and of equal length, but the end segment is about half the width of the preceding segment. The usual armature of the outer margin is present but there are no setae on the inner margins. The endopods are one-segmented and variously armed. The fifth legs are rounded lamellae bearing one outer seta and one short, terminal, curved spine.

The anal segment shows the operculum modified somewhat as in *Arenosetella*, the lateral margin is produced into upwardly curved claws which are immobile. The caudal rami show a similar tendency to the development of spurs both terminally and dorsally.

Male. Length 0.39–0.45 mm. Body as in female, but genital segment divided, giving a five-segmented urosome. First antennae seven-segmented and twice geniculate; other head appendages and swimming legs as in female. Fifth legs somewhat reduced, having only two short setae.



Text fig. 3.—*Neoleptastacus spinicaudatus* gen. et sp. nov.; whole animal  $\times 360$ , separate egg-sac  $\times 216$ , other figures  $\times 600$ .



This copepod resembles other members of this family in several respects. The rostrum is well developed and clearly articulated. In spite of the reduced first exopod, in which it approaches *Psammastacus* (Nicholls, 1935), it is perhaps more closely related to *Leptopontia* (T. Scott, 1902). This is shown by the structure of the mandible, the first endopod, and the anal operculum. The swimming legs are, however, in all cases more stoutly constructed and the endopods are only one-segmented.

### Fam. CANTHOCAMPTIDAE.

#### *Neoleptastacus spinicaudatus* gen. et sp. nov.

Occurrence. Leighton Beach, and Back Beach, Dongarra : washed from sand below six inches from surface ; both sexes, common.

Female. Length 0.28–0.30 mm. Body elongate, cylindrical, with a very slight taper towards each end. Rostrum small, rounded, fused with head : first antenna six-segmented, the second the largest and the fourth bearing a short, slender, sensory filament. Second antenna with the exopod reduced to a short seta : mandible palp two-segmented, the end segment with three setae : the maxillule was not seen : maxilla with two inner lobes : maxilliped short and stout.

The swimming legs have three-segmented exopods and two-segmented endopods : the rami are subequal in the first leg but the endopod shortens progressively posteriorly : the segments of the first and second endopods are subequal but in the other legs the end segment is very short. The exopods are without inner marginal armature of any description. The fifth legs consist of rectangular lamellae, in which the inner distal corner is produced into a spur-like process, outside of which are two very short and two longer setae.

The caudal rami are divergent, slightly shorter than the anal segment and a little longer than wide. Each bears terminally one large spine, and dorsally a smaller one : there are several setae.

One egg-sac is carried with, normally, two to four large eggs, but occasionally six eggs may be borne in which case they overlap instead of forming a linear egg-sac.

Male. Length 0.28–0.30 mm. Differs from the female only in having a five-segmented urosome and in the usual modification of the first antenna. The fifth legs do not differ appreciably from those of the female.

This copepod is related to *Paraleptastacus* by virtue of its small rostrum, fused with the head, but it differs in the structure and armature of the legs. The first legs show little difference except that the middle segment of the exopod is without a spine, but in legs 2–4 the endopod is much shorter than the exopod, and the end segment of this ramus is much reduced in the third and fourth legs. The exopods lack the inner modified setae found in *Paraleptastacus*, but one such, though not of the spatulate type, occurs on the second endopod.

The fifth legs are only one-segmented, the distal segment being obsolete, while the inner part of the basal segment is prolonged into a spine. This leg resembles the corresponding leg in *Leptastacus* in appearance, but here all the setae are external to the spine. The maxilliped shows a reduction from the condition found in *Paraleptastacus* (Wilson, 1932 : Nicholls, 1935, 1939).

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### 3.—WEST AUSTRALIAN FRESH WATER CALANOIDS (COPEPODA).

#### I.—THREE NEW SPECIES OF *BOECKELLA*, WITH AN ACCOUNT OF THE DEVELOPMENTAL STAGES OF *B. OPAQUA* n.sp. AND A KEY TO THE GENUS.

By W. S. Fairbridge, B.Sc.

Read 10th November, 1942.

#### INTRODUCTION.

*Boeckella opaqua* n.sp., was found in the neighbourhood of York (W.A.). It attracted attention by reason of its bright red colour and its somewhat peculiar habitat, which consisted of a number of small pools of rainwater that collect annually on a smooth granite outcrop, and dry off in the summer and autumn. Further investigation revealed that in the ponds of muddy water lying about during winter in the fields in the vicinity of this outcrop, there was another distinct species of *Boeckella*. Since such an apparently isolated habitat as that of *Boeckella opaqua* might be expected to harbour an unusual form, the species was examined and described. While constituting a distinct species, there is however nothing structurally unusual in it save perhaps the variability of the female fifth leg, which provides further evidence (if any were needed) of the faculty of this genus to produce species. However its discovery provided the opportunity to investigate the life history of a freshwater Centropagid. It was only when this was fully worked out that it was found that Oberg's paper on the development stages of *Centropages typicus* was unobtainable in Australia. Only a brief comparison with other forms has therefore been attempted. In itself the description of a freshwater Centropagid from Western Australia is of importance in being the first account of freshwater Copepoda from this State (with the exception that Professor G. E. Nicholls (1933) has mentioned the report of a *Boeckella* from the Porongorups and of *B. oblonga* (now *B. triarticulata* var. *oblonga* Brehm) from Western Australia); the other *Boeckella* found at York and one found in the grounds of the University are therefore described here as well. For aquatic organisms the South-West of Australia is isolated from the rest of the continent, and it is therefore not surprising that the three species found here should be new: rather, it is of interest that two of them should be so closely related to species from other parts of Australasia. The discovery is also of interest in view of the fact that this region supports a flora that is the oldest in Australia.

#### Order CALANOIDA.

#### Family CENTROPAGIDAE Sars, 1902.

#### Genus *BOECKELLA* DeGuerne and Richard, 1889.

#### *Boeckella opaqua* n.sp.

#### OCCURRENCE.

In shallow granite pools at Woodside, Hamersley (York), throughout the winter and spring of 1942. Of 72 adults taken on the 22nd of August, 54 per cent. were male.

## COLOUR.

Body, mouthparts, and swimming legs are at all stages heavily pigmented with red, often remaining longest in the spines and setae. All colour disappears in a few days on preservation in formalin.

## FEMALE.

Size : 1.26-1.43 mm. (Average of nine specimens : 1.31 mm.).

Head completely divided from thorax and the five thoracic segments distinct. Last thoracic segment produced on either side into a pair of irregular wings, the outermost being the larger and extending on the left nearly to the end of the genital segment, that on the right extending to half the length of the genital segment (Plate II., Figs. 1-3). Rostrum absent. Width of thorax to its length is 1 : 2.4. Abdomen three-segmented, the genital segment being symmetrical or nearly so, with a small irregular ventral swelling ; second segment shorter than anal segment, which in turn is nearly as long as caudal rami. Ratio of abdomen to thorax, 1 : 2.4.

Mouthparts : The mouthparts appear to be typical, but are described and fully figured for comparison with the developmental stages.

First antennae (Plate II., Fig. 1) 25-segmented, reaching nearly to end of genital segment ; proportions of segments 19-25 are 15 : 14 : 13 : 13 : 12 : 11 : 7. Endopod of second antenna (Plate I., Fig. 2) a little shorter than exopod, and its terminal segment bears eight lateral and seven terminal setae. Proximal endopod segment of mandible (Plate I., Fig. 3) bears four setae, and terminal segment eight setae. Epipod of first maxilla (Plate I., Fig. 4) bears nine long plumose setae ; exopod eight setae ; endopod is of four segments bearing six, two, two and the terminal segment four setae ; there are two inner lobes each bearing four plumose setae ; gnathobase has the usual stout teeth. Second maxilla (Plate I., Fig. 5) five-segmented ; the first with a lobe bearing three long setae ; second segment with three lobes each bearing two long setae and one shorter, stiffer seta ; third segment has one lobe similar to these ; fourth and fifth segments bear four and two setae respectively. Maxilliped (Plate I., Fig. 6) seven-segmented ; third segment bears three large setae and also a papilla carrying two setae ; fourth segment has three large setae, and the fifth and sixth, two larger setae ; the sixth has also a seta on the posterior margin ; terminal segment bears four setae.

Swimming legs : The general form of the swimming legs (Plate II., Figs. 6-9) is quite typical, but the setation of the second pair is variable as shown by the examination of two specimens of either sex, the setation of the right leg in one instance even differing from that of the left. The seta formula is, therefore given with the variations found in the second leg.

				Endopod.	Exopod.
p.1.	....	....	....	1.1.321	1.1.322
p.2.	....	....	....	1.1.422	1.1.422
				1.2.422	1.1.322
				1.2.322	
p.3.	....	....	....	1.2.422	1.1.422
p.4.	....	....	....	1.2.222	1.1.422

The fifth legs (Plate II., Figs. 10-15) also vary in their spines and setae. Ten pairs of legs were examined and the salient features are summarized :

1. The second basipod segment may have an outer plumose seta or not.
2. The first endopod segment may bear an inner seta on the right or left leg, or on neither or on both.



3. The second endopod segment is always unarmed, save for the fringe of fine hairs on its outer margin.
4. The third endopod segment may bear three, four, or five setae, and may be asymmetrical in this respect right and left.
5. The segmentation of the second and third endopod segments may be incomplete.
6. The terminal exopod segment bears on its inner margin two or three spines which vary in length and may be asymmetrical with respect to number and size right and left.

There is a single ovisac containing five to nine eggs.

#### MALE.

Size: 1.00—1.11 mm.

Head distinct from thorax and the five thoracic segments distinct. Last thoracic segment has rounded posterior corners (Plate II., Figs. 4 and 5). Rostrum absent. Width to length of thorax is 1:2.6. Abdomen five-segmented: anal segment a little shorter than caudal rami, and nearly twice the length of the fourth segment. Length of abdomen to that of thorax is 1:2.6.

Mouthparts: Right first antenna (Plate I., Fig. 1) 23-segmented and geniculate, with spines on segments 8, 10, 11, 12, 18, and 19, and extending back to the end of the furcae: left antenna 25-segmented but not reaching the base of furcae.

Fifth legs (Plate II., Fig. 16) are of usual form, with both endopods two-segmented and no lamella on second basal segment of left leg, though this segment is produced into a rounded prominence that does not reach the distal endopod segment and bears some very small hairs but is not denticulate.

#### LIFE HISTORY.

*Method.*—For breeding purposes the specimens were kept in 600 c.c. beakers and in a large round-bottomed jar, the water in these vessels being kept agitated by means of a plunger-jar system as described by Rees and Russell (1938). The Copepods bred freely in these vessels and it was possible to find the nauplii and ova in the beakers quite easily, and these could be captured for examination and dissection; but it was not possible to follow a single batch of eggs through their life history in such large vessels. Great difficulty was found in keeping the specimens alive when they were transferred to small petrie dishes. The adults would die within three or four days, and although ova would hatch, the resulting nauplii developed very slowly, taking from 27 to 48 hours to go through the first naupliar stage, and afterwards surviving for three days in the second naupliar stage, but none remaining longer alive. Under these circumstances the eggs would take from three and a half to five days to hatch. It seems probable that the water used in these dishes was unsatisfactory. In the beakers and the plunger-jar water taken from the original granite pools was used, but in order to get water free of nauplii for more exact breeding work other water was used. Tap water killed adult Copepods in three or four days, so rainwater from a galvanised iron tank and also rainwater caught in the open in a clean porcelain dish was used, but the result was the same. Both the salinity and pH of the water from the granite pools was found to be that of rainwater, whereas tap water had a salinity nearly three times that of the water from the pools and the pH also was higher. No attempt was made to aerate the water in the small vessels.

After the first week the beaker that had been filled with water from the pools became discoloured with a greenish growth, which proved to be *Euglena*. While no gut is visible in the first nauplius stage, later stages were found to have greenish matter in their gut and this was assumed to be the *Euglena* since no diatoms were present in quantity. A second catch of specimens was made later, and fresh water collected which did not develop this growth of *Euglena*. These specimens were fed on a mixed culture of diatoms obtained by enriching freshly-caught rainwater with Miquel's solutions A and B as described by Allen (1914) for seawater, and inoculating this with detritus from the pools.

#### THE OVA.

The number of ova in an ovisac varies from five to nine. They are subspherical and 0.115—0.122 mm. in diameter. The eggshell itself is quite colourless, but the eggs appear opaque and granular at all ages on account of their contents which are of the bright red that characterises the adult. They are easy to see lying on the bottom of the beaker, or attached to a female. These ova cannot be resting-eggs for they collapse when allowed to dry up.

#### THE NAUPLII.

As mentioned above, it was not possible to measure the time taken to pass through the separate stages, but on two occasions a maximum time for the development from the egg to the first copepodid stage was obtained, namely 19 days and 21 days. During this period temperatures of a similar beaker of water standing beside the others were taken at about 9.30 a.m. and 5 p.m. each day; these temperatures varied from 14.0°C. to 17.4°C. with an average of 15.6°C. Clearly the temperature of the laboratory would be more constant than on the exposed top of a hill, and this would affect the time taken to pass through the developmental stages.

The body and the mouthparts of the nauplii are coloured a bright red like the adult. When first hatched they are packed with red oil globules and no gut is visible, but during stage II. these oil globules disappear and the gut becomes visible.

Difficulty was found in distinguishing the various stages while retaining the specimen still alive, since it is almost impossible to manipulate them with a glass needle without damage, and the differences between some of the stages are such as require special orientation of the specimen if it is to be identified without dissection. In particular it is not easy to distinguish between stages I. and II. and between IV. and V. (see below).

All measurements of the nauplii exclude the caudal setae and spines.

##### *Nauplius Stage I.*

Length: 0.158—0.173 mm. (Three specimens).

Very globose, the caudal region smoothly rounded in lateral view and tucked under (Plate III., Fig. 1) bearing two small unequal setae of which the left is the larger; labrum large and naked, lying closer to the body than in the later stages and therefore less conspicuous; rostral prominence inconspicuous or absent. A large dark red eyespot present.

First antenna (Plate IV., Fig. 1): Of three segments; the first with one ventral, the second with two ventral setae; terminal segment with three very large plumose setae at its apex which remain most conspicuous throughout all the nauplius stages, being much thicker and longer than any others.



Second antenna (Plate V., Fig. 1) : Coxa with one small masticatory hook ; basis with one small masticatory hook and two setae ; endopod with two lateral and two stronger terminal setae ; exopod of five segments, the terminal bearing two setae and the others one each.

Mandible (Plate V., Fig. 7) : Coxa with one small masticatory hook ; basis with two setae showing little or no modification ; endopod with six setae arranged in pairs ; exopod of four segments, the terminal bearing two setae and the others one each.

This stage is not clearly distinguishable from the next without dissection, particularly since the first antennae bears the same number of setae. The difference is seen best in side view, when the caudal region of the body is seen to be curved smoothly under, and the somewhat curved labrum to lie along the body. These two features seem to have been impressed upon the larva by the necessity to conform to a spherical egg-shell, and they are thrown off at the first moult. In addition to the above differences, stage I. when first hatched is more heavily pigmented or more opaque than other stages and this is often a useful guide, though the opacity goes after a few hours, especially from the first antennae.

### *Nauplius Stage II.*

Length : 0.180—0.190 mm. (Three specimens.)

Still very squat in lateral view (Plate III., Fig. 2) but with caudal region ending bluntly and directed backwards (not ventrally) and with labrum projecting downwards from the body and very conspicuous ; in ventral view (Plate IV., Fig. 8) the posterior region appears rather more elongate and oval, the anterior end somewhat rectangular and with a ventral hyaline rostral prominence ; in this and in all subsequent stages the labrum is clothed at the tip with fine hairs. The eyespot is large.

Throughout the subsequent stages the body becomes more elongated and pyriform rather than oval, the labrum relatively smaller but still very conspicuous in lateral view (in the diagrams of the nauplii from the ventral surface, the labrum appears smaller than it is, owing to its projecting ventrally).

First Antenna (Plate IV., Fig. 2) : As in stage I., but with a number of stiff hairs on ventral margin of terminal segment.

Second Antenna (Plate V., Fig. 2) : Coxa with fine seta and a very strong masticatory hook ; basis with the masticatory hook stronger than before, and two setae ; endopod with two lateral and three strong terminal setae ; exopod as in stage I., but with two setae on the proximal segment.

Mandible (Plate V., Fig. 8) : Coxa with the masticatory hook stronger ; basis with two masticatory hooks ; endopod with eight setae the proximal pair somewhat modified for feeding ; exopod as in stage I., but the proximal segment bears two setae.

### *Nauplius Stage III.*

Length : 0.216—0.230 mm. (Five specimens.)

In this and subsequent stages the head has a very distinctive profile, due largely to the rostral prominence. The caudal region is cleft, each ramus

bearing a stout inwardly curved plumose spine ; interior to this spine and on the dorsal surface of each ramus is inserted a slender seta, the right one usually carried either vertical or lying forwards along the back (Plate III., Fig. 3) and therefore not seen in ventral view (Plate IV., Fig. 9) giving an appearance of asymmetry. The exact point of insertion of these two setae is not clear, but they probably do exhibit a slight asymmetry in this respect. Around the tip of each caudal ramus is a row of fine spinules.

First antenna (Plate IV., Fig. 3) : As in stage II., but terminal segment has an additional ventral and two dorsal setae.

Second antenna (Plate V., Fig. 3) : As in stage II., but coxa with another masticatory hook and basis with three unmodified setae ; endopod with a further lateral and terminal seta ; exopod of six segments, the division between the proximal two being incomplete ; first segment bears two and the terminal three setae.

Mandible (Plate V., Fig. 9) : Coxa showing the rudiments of a mandibular blade ; basis with another masticatory hook ; endopod with seven unmodified setae ; otherwise as in stage II.

#### *Nauplius Stage IV.*

Length : 0.246—0.274 mm. (Three specimens.)

The bifurcation of the caudal region deeper, and the spines curved inwards (Plate IV., Fig. 10 ; Plate III., Fig. 4).

First antenna (Plate IV., Fig. 4) : As in stage III., but terminal segment bears three setae on the ventral and four on the dorsal margin ; dorsal margin has also a pair of small hairs.

Second antenna (Plate V., Fig. 4) : As in stage III., but basis carries four unmodified setae.

Mandible (Plate V., Fig. 10) : Blade now well developed, toothed, and carrying a thick plumose seta ; basis with four masticatory spines and two unmodified setae ; endopod with eight unmodified setae arranged in pairs ; exopod as in stage III.

First maxilla (Plate V., Fig. 13) : Present as a bifid lobe bearing 10 setae and taking an active part in the swimming (and no doubt feeding) of the nauplius.

#### *Nauplius Stage V.*

Length : 0.280—0.317 mm. (Four specimens.)

The body shows the first indication of the future segmentation of the metasome (Plate III., Fig. 5) : Caudal rami more marked, the spines being divergent. (Some specimens show indications of the second pair of caudal spines that are developed fully in stage VI., placed interior to and a little ventral to the old spines.)

First antenna (Plate IV., Fig. 5) : As in stage IV., but terminal segment bearing four setae on the ventral and six on the dorsal margin ; a tuft of hairs also present on dorsal margin.



Second antenna (Plate V., Fig. 5): As in stage IV., but endopod with four lateral and five terminal setae; exopod of seven free segments, the second bearing four setae and the first none.

Mandible (Plate V., Fig. 11): Blade somewhat larger, otherwise no change.

First maxilla (Plate V., Fig. 14): Of five lobes, the largest showing an incipient division to form another small one; two proximal lobes unarmed, inner lobe carries two, terminal lobe seven, and the outer lobe five setae.

Second maxilla: Consists simply of rudimentary lobe bearing two apical setae.

### *Nauplius Stage VI.*

Length: 0.338—0.372 mm. (Six specimens.)

The incipient thoracic segments are more clearly marked (Plate III., Fig. 6); another smaller pair of caudal spines are borne interior to the old ones (Plate IV., Fig. 12).

First antenna (Plate IV., Fig. 6): Terminal segment bears five setae on the ventral margin and six on the dorsal, with a row of fine hairs at the proximal end of this margin. In some specimens this segment shows an incipient division into five segments.

Second antenna (Plate V., Fig. 6): As in stage V., save for a partial separation of segment two of exopod.

Mandible (Plate V., Fig. 12): As in stage V., save that basis carries one more small seta, and endopod shows a trace of being divided into two segments.

First maxilla (Plate V., Fig. 15): The principal lobes are now clear: epipod bears one seta, exopod six, endopod and its two associated lobes bear  $9 + 3 + 3$  setae, and gnathobase four setae.

Second maxilla (Plate V., Fig. 16): Of three segments only, though five lobes each bearing two setae are distinct; terminal portion bears three setae.

Maxilliped (Plate V., Fig. 17): Very rudimentary, consisting of three segments, terminal one bearing two setae.

TABLE I.—The Naupliar Appendages.

#### *First Antenna.*

Stage.				1st Segment.	2nd Segment.	3rd Segment.
I.	...	...	...	S	2S	3P
II.	...	...	...	S	2S	3P
III.	...	...	...	S	2S	3P, 3S
IV	...	...	...	S	2S	3P, 7S
V.	...	...	...	S	2S	3P, 10S
VI	...	...	...	S	2S	3P, 11S

*Second Antenna.*

Stage,	Coxa,	Basis,	Endopod,	Exopod,
I. ... ..	M	M, 2S	2S + 2P	P, P, P, P, 2P
II. ... ..	M, S	M, 2S	2S + 3S	2P, P, P, P, 2P
III. ... ..	2M, S	M, 3S	3S + 4S	$\overbrace{2P + P}^3$ , P, P, P, 3P
IV. ... ..	2M, S	M, 4S	3S + 4S	$\overbrace{2P + P}^3$ , P, P, P, 3P
V. ... ..	2M, S	M, 4S	4S + 5S	0.4P, P, P, P, P, 3P
VI. ... ..	2M, S	M, 4S	4S + 5S	$\overbrace{0.3P + P}^4$ , P, P, P, P, 3P

*Mandible.*

Stage,	Coxa,	Basis,	Endopod,	Exopod,
I. ... ..	M	2S	6S	S, S, S, 2S
II. ... ..	M	2M	2M, 6S	2S, S, S, 2S
III. ... ..	M	3M	2M, 7S	2S, S, S, 2S
IV. ... ..	M, B	4M, 2S	2M, 8S	2S, S, S, 2S
V. ... ..	M, B	4M, 2S	2M, 8S	2S, S, S, 2S
VI. ... ..	M, B	4M, 3S	2M, 2S, 6S	2S, S, S, 2S

S = Seta.

P = Plumose seta.

M = Masticatory hook.

B = Toothed

mandibular blade.

## THE COPEPODIDS.

The development through the copepodid stages is quite typical. All measurements were made to the end of the caudal rami.

*Copepodid Stage I.*

Length : 0.35 - 0.45 mm. (Three specimens.)

Thorax five-segmented, and abdomen of one segment only ; caudal rami well developed and bearing the full number of setae as developed in the adult, though the outermost terminal seta and the middle one are very short (Plate VIII., Fig. 1).

First antenna (Plate VI., Fig. 1) : 11-segmented, the fourth showing indications of subdivisions.

Second antenna (Plate VI., Fig. 5) : Already bears all the features of the adult organ, the only change throughout the copepodid stages being in the number of setae on the terminal endopod segment. Coxa bears one seta ; basis bears two ; first endopod segment bears a pair laterally ; second endopod segment bears a tuft of four lateral and five apical setae. Exopod is of the usual seven segments, segments three, four, five, and six being very short ; each segment bears one long seta, save the second which has three, and the last, which has three apical setae.



**Mandible** (Plate VI., Fig. 7): As in the second antenna, this organ has all the adult features developed, the only change through the copepodid stages being an increase in the number of apical setae of the endopod. The blade is well-developed but lacks the seta of the nauplii. Basis bears four setae: first endopod bears four setae laterally, and second endopod six apical setae: exopod is of four segments, each bearing one seta, save the last, which has three.

**First maxilla** (Plate VI., Fig. 9): This organ is not easy to examine owing to the way in which the lobes overlies one another in the natural condition. However, it seems that all the lobes of the adult organ are present. Epipod bears four long setae and exopod seven setae; endopod is of two distinct segments, the apical bearing four setae and the proximal two pairs of setae indicating an incipient division.

**Second maxilla** (Plate VI., Fig. 11): This is of five segments. There are five distinct endites, each bearing two long and one shorter seta, as in the adult; a very small lobe distal to these bears a single seta; the apical segment bears three setae and the sub-apical two.

**Maxilliped** (Plate VI., Fig. 12): This consists of only four distinct segments, though the third shows an incipient division to four segments. First segment has three (possibly four) protuberances bearing one, two, and three setae; second segment has two setae, the third one, and the apical segment three setae.

The first two pairs of swimming legs only are developed (Plate VII., Figs. 1 and 2), the third pair being rudimentary.

### *Copepodid Stage II.*

Length: 0.52—0.62 mm. (Average of nine specimens: 0.58 mm.)

Thorax of five segments; abdomen shows an incomplete division to two segments; caudal setae are of the same length relative to each other as in the adult (Plate VIII., Fig. 2).

**First antenna** (Plate VI., Fig. 2): Of 16 segments.

**Second antenna** (Plate VI., Fig. 6): As in stage I., but both rami are longer and slenderer; in particular the second exopod segment has lengthened; terminal endopod segment bears four lateral and six apical setae.

**Mandible** (Plate VI., Fig. 8): As in stage I., save that basis is larger and slenderer, the coxa being more clearly marked off; apical endopod segment bears six setae as in stage I.

**First maxilla** (Plate VI., Fig. 10): All the lobes of the adult organ are clearly present; epipod bears six long setae and exopod seven setae; endopod as in stage I.; there is an increase in the number of teeth on gnathobase.

**Second maxilla**: As in the adult.

**Maxilliped** (Plate VI., Fig. 13): Consists of five segments. On first segment are four bulges bearing one, two, two and three setae; second segment has two setae; third segment three setae; the fourth one seta; and the fifth four setae.

First three pairs of swimming legs present (Plate VII., Figs. 3-5), the fourth pair being rudimentary.

*Copepodid Stage III.*

Length : 0.67—0.75 mm. (Six specimens.)

Abdomen of two distinct segments (Plate VIII., Fig. 3).

First antenna : Of 23 possible segments, but segments two to 10 are very indistinct and probably some of them are incomplete.

Second antenna : As in stage II., but second endopod segment bears five lateral and six terminal setae.

Mandible : As in stage II.

First maxilla : As in the adult.

Second maxilla : As in the adult.

Maxilliped : Consists of six segments. First segment agrees with stage II. ; the second and third bear three setae ; the fourth two ; the fifth one on the anterior and one on the posterior margin ; the sixth four setae. Four pairs of swimming legs present (Plate VII., Figs. 6-9), fifth pair being rudimentary.

*Copepodid Stage IV.*

Length : Female, 0.83—0.94 mm. (Average of seven specimens, 0.90 mm.)

Male, 0.74—0.80 mm. (Four specimens.)

In dorsal view posterior thoracic corners of female do not appear produced (Plate VIII., Fig. 4) ; in side view they are pointed, the points turned downwards. In male posterior thoracic corners rounded. In both sexes abdomen of three segments, the middle one being very short.

First antenna (Plate VI., Fig. 3) : Of 24 segments, though segment four shows a trace of segmentation.

Second antenna : As in stage III.

Mandible : As in stage III.

First maxilla : As in the adult.

Second maxilla : As in the adult.

Maxilliped : Of six segments ; first segment as in the adult ; second segment with three setae ; third segment with four setae ; fourth segment with two setae ; fifth segment with one seta on the anterior and one on the posterior margin ; apical segment has four setae as in the adult.

Four pairs of swimming legs present (Plate VII., Figs. 10-13), and the fifth legs both rami of which in both male and female are one-segmented. In the female (Plate VII., Fig. 18) exopod bears three outer spines, an apical, and three small inner spines ; endopod bears one outer, one apical, and two inner spines ; there is an outer marginal seta on basipod. In the male (Plate VIII., Fig. 9) exopod bears two outer, two apical, and two very small inner spines ; both endopods bear two spines on inner margin near apex, and lower down a minute triangular spine.



*Copepodid Stage V.*

Length : Female, 1.00—1.08 mm. (Average of nine specimens, 1.04 mm.)

Male, 0.85—1.00 mm. (Average of six specimens, 0.94 mm.)

Female posterior thoracic corners asymmetrical in dorsal view (Plate VIII., Fig. 5), that on the left being the longer ; in lateral view corners pointed and turned down and there is an indication of the future inner lobes either side (Plate VIII., Fig. 6) : abdomen three-segmented. Male posterior thoracic corners rounded (Plate VIII., Fig. 7) ; abdomen four-segmented, the fourth being the longest.

First antenna : In female this is 25-segmented, as in adult. In the male (Plate VI., Fig. 4) the right is of 25 segments with spines on segments eight, 10, 11, 19, and 20, though the spines on the first three of these segments are difficult to distinguish from the setae ; left antenna is 25-segmented.

Second antenna : As in adult, save that endopod bears seven lateral and seven terminal setae, and terminal exopod segment without lateral seta.

Mandible : As in adult, but second endopod segment bears seven setae.

First maxilla : As in the adult.

Second maxilla : As in the adult.

Maxilliped : As in the adult.

Swimming legs have the same setation as the adult (Plate VII., Figs. 14–17). Female fifth legs (Plate VII., Fig. 19) have a two-segmented exopod, the terminal segment bearing the large inner spine not yet fully developed, and in addition three smaller inner spines, an apical and three outer spines ; endopod shows an indication of segmentation into two and bears five spines near its apex ; basipod bears an outer marginal seta. Male right fifth exopod (Plate VIII., Fig. 8) is three-segmented and the left two-segmented, though there are sometimes indications of a division in the second segment ; each exopod bears one long apical spine ; both endopods are two-segmented, that on the right bearing a single subterminal spine.

TABLE II.—The Copepodid Appendages.

*Second Antenna.*

Stage.			Coxa.	Basis.	Endopod.	Exopod.
I.	...	...	S	2S	2S. 4S, 5S	P. 3P. P. P. P. P. 3P
II.	...	...	S	2S	2S. 4S, 6S	P. 3P. P. P. P. P. 3P
III.	...	...	S	2S	2S. 5S, 6S	P. 3P. P. P. P. P. 3P
IV.	...	...	S	2S	2S. 6S, 6S	P. 3P. P. P. P. P. 3P
V.	...	...	S	2S	2S. 7S, 7S	P. 3P. P. P. P. P. 3P
VI.	...	...	S	2S	2S. 8S, 7S	P. 3P. P. P. P. P. 3P

*Mandible.*

Stage.			Coxa.	Basis.	Endopod.	Exopod.
I.	...	...	O	4S	4S. 6S	S. S. S. 3S
II.	...	...	O	4S	4S. 6S	S. S. S. 3S
III.	...	...	O	4S	4S. 6S	S. S. S. 3S
IV.	...	...	O	4S	4S. 6S	S. S. S. 3S
V.	...	...	O	4S	4S. 6S	S. S. S. 3S
VI.	...	...	O	4S	4S. 6S	S. S. S. 3S

*Second Maxilliped.*

Stage.			Segments number.						
			1.	2.	3.	4.	5.	6.	7.
I.	...	...	O, P, 2P, 3P	2P	S				3S
II.	...	...	P, 2P, 2P, 3P	2P	2S, S	S			4S
III.	...	...	P, 2P, 2P, 3P	3P	2S, S	2S	S, S		4S
IV.	...	...	P, 2P, 3P, 4P	3P	2S, S	2S	S, S		4S
V.	...	...	P, 2P, 3P, 4P	4P	2S, 3S	3S	2S	2S, S	4S
VI.	...	...	P, 2P, 3P, 4P*	4P	2S, 3S	3S	2S	2S, S	4S

## DISCUSSION.

As mentioned above, Oberg's (1906) paper on the developmental stages of *Centropages hamatus* was not obtainable, nor were Grandori's papers (1912 and 1925) on *C. kroyeri* and *C. typicus*. But Gurney (1931) gives a brief account of the development of *C. hamatus*.

The general form of the nauplius of *Boeckella opaquia* and the stages at which the chief changes take place in the copepodids agree with those for *Centropages hamatus*. The chief difference centres around the male fifth leg. This appears at stage IV. and in *Boeckella* is distinguished from the female by the nearly equally long spines at the apex of the exopod. In the next stage the difference is even more marked, the male legs being considerably modified, whereas in *C. hamatus* they are quite normal (both rami being as yet two-segmented); in particular *Boeckella* shows a marked loss of setae from both rami. Thus the whole change to the modified adult condition takes place in the last moult in the case of *C. hamatus*, but is gradually led up to in *Boeckella*—an understandable difference, since *Boeckella* has a fifth leg considerably more modified than *Centropages*. The male prehensile antenna of stage V. seems to agree fairly well in the two species.



Differences in the nauplii are largely due to the more asymmetrical development of the two caudal setae in *Centropages* (though essentially the same structures are present in both), and the absence of setae on the ventral margin of the first antenna of this genus. Both genera agree in having a large rostrum.

A comparison of the male fifth leg in the adult and in copepodid V. makes it clear that the terminal spine of the left leg consists of two terminal exopod segments fused, while the terminal spine on the right consists of the third exopod segment only. Comparing the three stages IV., V., and VI., it is also clear that the development of the two endopods has been retrogressive; a fact which bears out the theory that the genus *Pseudoboeckella* is older than *Boeckella* (see Marsh, 1924, p. 27). Similarly in the adult female, the presence of fewer inner spines on the third exopod segment, and of fewer terminal spines on the endopod of some specimens is an indication of retrogression in this respect. Finally attention may be drawn to the essential similarity of the fifth legs in both sexes at stage IV.

#### BIONOMICS.

The spot where *Boeckella* *opauqua* was found was the summit of a hill rising about 200 feet above the general level of the plain. On the top of the hill and down one side an exfoliated granite outcrop was exposed, scattered over which in an area of about a quarter of a square mile were numerous pools varying from 12 feet in diameter to mere puddles, and never more than six inches deep. There was sometimes a thin layer of black sediment in these pools, and sometimes some coarse sand, and often nothing, leaving a floor of clean granite. Thick wet pads of moss were everywhere and often these came down to the edge of the water.

*Boeckella* was found swarming in many of these pools irrespective of size, while from many it was quite absent, or only sparingly found. They could readily be seen mainly around the rim of a pool swimming slowly at the bottom or nearer the surface. If the water was disturbed they would give a number of leaps and then settle down again quickly to their slow swimming action. Associated with them were Cladocera, Ostracods and tadpoles. It is interesting to note in connection with the colouration of this species, that Copepods (especially *Diaptomus*) from high altitudes in the European Alps are supposed to show a tendency to red colouration. Valkanov (1931) summarises two possible explanations: that the red colour is due to feeding, and that it is due to temperature. He dismisses both suggestions, but does not mention the possibility that heavy red pigmentation may be protective against the intense light at high altitudes in shallow pools of clear water. Such an explanation would be suitable here, where the atmosphere is clear even at such slight elevation above sea-level (550 ft.) and where the sun stands considerably higher in the sky than it does in Europe.

The York district is Wandoo country with a rainfall of nearly 20 inches, all of which, except for a few storms in summer, falls between March and October. These pools therefore must be dry for at least three or four months of the year. Though there are frosts in winter, it is unlikely that ice ever forms in the pools, or, if found, remains through the subsequent day. The pH of the pools was calculated from colour charts, using Phenol Red and Cresol Red; this was found to be 8.0. The salinity was the same as that of rainwater. Since these are rather peculiar conditions, and a different species of *Boeckella* was found in ponds at the ordinary level of the plain, it seems probable that *Boeckella opauqua* has a very limited distribution, probably occurring only in

pools collecting annually in similar granite outcrops in the Wheatbelt. On a visit to the same locality in the previous year the Copepods were present.\*

From the breeding experiments it seems unusual for the species to remain alive long after laying its first batch of eggs. There was fairly certain evidence on three occasions that a female produced more than one batch of eggs (as seems to be the rule with most species) but this would not appear to be usual.

### *Boeckella pellucida* n.sp.

#### OCCURRENCE.

This species was taken at two localities : (1) Five males and 33 females from muddy pools not more than six inches deep, at Woodside, Hamersley (York) August, 1942 ; (2) from a small pond of slightly muddy water less than two feet deep in laterite, by the roadside between Mount Barker and the Porongorups, October, 1942. In the first instance the Copepod was not common while Cladocera were swarming ; in the latter the Copepod was swarming. In both localities the ponds would be dry during the summer.

#### COLOUR.

Eggs and body pinkish white after preservation in formalin ; when alive, colourless.

#### FEMALE.

Size : Locality (1), 1.85—2.6 mm. (Average of 11 specimens : 2.0 mm.) Locality (2), 1.5 mm.

Head completely divided from thorax by a faint line ; five thoracic segments distinct, the fifth produced posteriorly to a pair of asymmetrical wings either side, the outermost of which extends on the right side from two-thirds to the end of the genital segment and on the left is always longer than the right and may reach to the end of second abdominal segment (Plate IX., Figs. 2 and 3). Width of thorax to its length, 1 : 2.6. No rostrum. Abdomen, three-segmented ; genital segment large and rather asymmetrical, the right side being more developed at anterior end ; there is a slight ventral prominence. Left caudal ramus usually a little longer than the right and terminal setae short and stout. Length of abdomen to thorax is 1 : 2.2.

Mouthparts : First antennae, 25-segmented and reaching to between the end of the genital segment and the end of the caudal rami ; proportions of last six segments are 17 : 17 : 15 : 15 : 12 : 7. The other mouthparts agree with those figured for *Boeckella opaqua*.

Swimming legs : The seta formula differs slightly from *Boeckella opaqua*.

			Endopod.	Exopod.
P1	....	....	1.1.321	1.1.322
P2	....	....	1.2.422	1.1.422
P3	....	....	1.2.422	1.1.422
P4	....	....	1.2.322	1.1.422
P5	....	....	0.1.322	1.1.222

Fifth legs (Plate IX., Fig. 6) of usual pattern, and terminal exopod segment bears seven sharp spines, the terminal spine being longer than the segment.

There is a single ovisac containing from 25 to 50 eggs.

\* On December 1st and December 20th, 1942, Hamersley had 60 and 100 points of rain respectively. On December 28th, an opportunity was taken to visit the locality and a few of the pools were found to contain still a little water. In all of these there were a few Ostracods and in one case they were swarming ; but there were no Cladocera and no Copepods. This observation would seem to show that the stage in which this species of *Boeckella* resists drought (probably as ova) is not stimulated to continue development simply by a supply of rainwater. Possibly temperature, or the elapse of a time-interval, or a combination of factors, is necessary.



## MALE.

Size : Locality (1), 1.5—1.6 mm.; Locality (2), 1.4 mm.

Head incompletely divided from thorax, but the fifth thoracic segment distinct and with rounded posterior corners. (Plate IX., Figs. 4 and 5). Width of thorax to its length, 1 : 2.6. No rostrum. Abdomen, five-segmented and its length to that of thorax is 1 : 2.4.

Mouthparts : Right first antenna (Plate IX., Fig. 1) 23-segmented with a spine on segments eight, 10, 11, 14, 15, and two on segments 12 and 16 ; left first antenna, 25-segmented and extending almost to base of caudal rami:

Swimming legs : Their setation agrees with that of the female. The fifth feet (Plate IX., Fig. 7) are of the type of *Boeckella triarticulata* var. *oblonga* Brehm (1939) and *B. fluvialis* Henry (1922). Right endopod is of one segment with a pointed apex and a triangular expansion on its inner basal margin. The right leg differs from *B. fluvialis* in having no pointed process from the second basal segment. Left endopod is clearly two-segmented with proximal segment expanded and distal one rounded at tip. There is a serrate lamella on second basal segment, the inner margin of which is curved (not rectangular as in *B. fluvialis*) and produced apically to a sharp point.

In addition to the differences mentioned above, this species may be distinguished from *B. fluvialis* by the length of the first antennae which never reach the end of the caudal rami, whereas in *B. fluvialis* they extend beyond by two segments at least.

Apart from the two-segmented left endopod, the male fifth legs resemble also *B. triarticulata* var. *oblonga*, but differ in the acute triangular apex of the serrate lamella and in the size of the inner basal expansion of the right endopod. It is clear however that *B. pellucida* is closely related to this species which comes from New South Wales and Victoria.

***Boeckella lacuna* n.sp.**

## OCCURRENCE.

A small muddy pond in clay in the University grounds, that dries up in summer.

## COLOUR.

Body hyaline, but at the bases of the limbs there is often some blue pigmentation.

## FEMALE.

Size : 1.5—1.7 mm.

The division between head and thorax appears to be incomplete, but the four thoracic divisions are distinct, and the posterior thoracic corners are drawn out into a pair of sharp-pointed lobes either side, the outermost of which are longer and extend to less than half the length of the genital segment (Plate X., Fig. 1). Genital segment very nearly symmetrical ; rest of abdomen typical and the caudal setae rather short and stout. Ratio of thorax to abdomen, 2.4 : 1. Rostrum absent.

First antennae 25-segmented and extending to base or to the end of caudal rami. The other mouthparts agree with those for *B. opaqua* n. sp.

The seta formula for the swimming legs is the same as that of the preceding species. The fifth leg is typical in its general form for the genus, the endopod being fully armed and plumose along its inner margin. The third exopod segment bears seven spines but shows considerable variation in the length of the inner basal spine; this is most often either as long as the next (as in *B. pellucida* n. sp.) or reduced to the limit shown in Plate X., Fig. 6, intermediate stages are less frequent; the exopods may be symmetrical or asymmetrical in this respect (seven specimens were dissected).

There is a single ovisac containing about 15 eggs.

#### MALE.

Size: 1.3 mm.

Head entirely separated from thorax, and posterior thoracic corners not produced and in side view appear evenly rounded. Right caudal ramus is somewhat shorter than the left. Ratio of thorax to abdomen, 2.4:1. No rostrum.

First antenna is geniculate on the right side, bearing a spine on segments eight, 10, 11, and 17; left antenna does not reach the base of caudal rami.

The fifth legs are very similar to *B. pellucida*, differing only in minor features, but principally in the lengths of the endopods relative to the exopod segments and in the lamella on the second basal segment of the left leg, two aspects of which are shown (Plate X., Figs. 7 and 8). Inner margin of first exopod segment of left leg is densely clothed with fine hairs.

Clearly this species is very closely related with the preceding and hence with the *B. triarticulata* group (see below, page 41). It may be distinguished from *B. pellucida* n. sp. by the short posterior thoracic wings which are a constant feature, in conjunction with the slighter and sometimes variable differences in the male and female fifth legs.

#### THE NAUPLII.

This species bred freely in the laboratory in a large open porcelain dish and also in petrie dishes and watch-glasses, and all the nauplius stages were obtained. These differed from *B. opaqua* n. sp. only in a few details of the setation of the second antenna and the first maxilla in some of the stages; in the sixth stage the maxilliped was unsegmented, and from the first appearance of the plumose caudal spines these were more seta-like than spinous. The nauplii were colourless. Apart from these differences the nauplii in their general form and in their appendages were strikingly like those of *B. opaqua*, as appears to be the rule with species of the same genus.

#### A NOTE ON THE DISTRIBUTION OF *BOECKELLA*.

The geographical distribution of this genus is perhaps its most interesting feature. *Boeckella* and *Pseudoboeckella*\* are found in Kerguelen and New Amsterdam Islands, Australia, Tasmania, New Zealand, South America, and one species in Mongolia (Sars, 1903, and Kiefer, 1937). In fact the genera seem to fill for South America and Australasia the same position that *Diaptomus* does for the Northern Hemisphere. In other words we are faced with the old problem of a distinctive Australasian fauna allied to that of South America and islands in the Indian Ocean but not to South Africa. In addition it appears that *Boeckella* and *Pseudoboeckella* are confined to temperate

\* The separation of the two genera is convenient rather than natural, being based on the degree of reduction of the right fifth endopod of the male—an organ that is clearly undergoing a gradual process of reduction.



regions; this is indicated by their distribution in Australia (though little investigation has been done in the sub-tropical regions) and in South America, where Patagonia and southwards is the main area for *Boeckella* and *Pseudoboeckella*, the genera extending northwards only along the chain of the Andes. The temperate distribution of these Copepods is important in showing that whatever Australia's connection with South America may have been, it was (at that time) in temperate latitudes. It may be argued that *Boeckella* does not extend into the tropics because of the competition of *Diaptomus* (found throughout the South American tropics and in the Malay Archipelago); we know, however, that *Diaptomus* thrives in a temperate climate, so that conversely its migration southwards would appear to be hindered by the competition of *Boeckella*. In Australia itself only three species of *Diaptomus* were recorded by Henry in 1922, and none were found south of 28° 50' south.

A further interesting point has been touched on by Nicholls (1933), namely, that the Cladoceran genus *Daphniopsis* has been recorded only from this State, Kerguelen Island, and Mongolia, and that this distribution is paralleled by that of *Boeckella*. He says (p. 124) that *B. oblonga* Sars (now *B. triarticulata* var. *oblonga* Brehm) which is very similar to *B. orientalis* Sars (the Mongolian species of *Boeckella*) has been found in Western Australia, but this report has not been published and was possibly a mistaken identification; nevertheless weight is given to the general argument by the establishment (see below), of very close affinities in a group of species and varieties which includes *B. orientalis* and two species from this State. This provides some evidence that the Mongolian colony of *Boeckella* was carried thither from Western Australia rather than from other parts of this continent.

#### A KEY TO THE GENUS *BOECKELLA*.

Since the publication of Marsh's key in 1924 seven new species (exclusive of those described in this paper) have been created, and four varieties; it is therefore of some use to bring this key up to date. The task of making a key is rendered more difficult by the marked tendency for species of this genus to vary even within a single local colony, and also the inadequate figures and descriptions supplied for some of the species. One species only however, has for this reason been omitted from the revised key, namely *Boeckella major* Searle (1938) from Victoria (Australia). This species may probably be recognised by its large size (♀ : 3.35 mm., ♂ : 2.75 mm.) and large posterior thoracic processes which extend almost to the third abdominal segment. This is all the description supplied; in addition there is a figure of the male fifth legs showing a three-jointed right endopod, the left endopod being wanting.

Brehm (1939) tabulates some characteristics from two descriptions of *B. triarticulata* Thomson for comparison with those of *B. oblonga* Sars and a new variety of *triarticulata*. He reaches the conclusion that, retaining the name *triarticulata* for one of these forms, the other three must be regarded as varieties of it (the name *B. oblonga* Sars therefore lapses in favour of *B. triarticulata* var. *oblonga* Brehm). It seems best to accept these varieties, at least until it can be shown that they are not constant. In the species *triarticulata* we are faced with what seems to be a widely distributed and variable group of forms, since its varieties are found from New Zealand to New South Wales and South Australia, and the two new species *B. pellucida* and *B. lacuna* described in this paper from Western Australia (and possibly *B. orientalis* Sars from Mongolia) are closely related to it. Specific rank has been given to the Western Australian forms since in both cases the description was made from a number of individuals, and in the case of *B. pellucida* distinguishing

characters were found constant in two widely separate localities. Nevertheless *B. triarticulata* Thomson and its three varieties *Sarsi*, *oblonga* and *quarta*, with *B. pellucida* and *B. lacuna* n. spp. and *B. orientalis* Sars form a group in which species can be separated only by the combinations taken by various characters that are evidently readily varied in the group's evolution.

Brehm (1937) criticises Marsh for using the segmentation of the endopod of the male fifth leg as a character on which to base his key, saying that the segmentation here is frequently difficult to determine, and in one form (*B. bergi* var. *cornuta*) is incomplete. The variability in the number of spines on the exopod segment of the female fifth leg in *B. opaqua* n. sp. renders this feature also of doubtful value and emphasises the unreliability of descriptions made from only one or two specimens of a species. To alter these points, however, would have meant recasting the whole key, and this was not thought worth while in view of the difficulty of obtaining literature.

## KEY.

1. Terminal exopod segments of female fifth legs  
with two spines ... .. *minuta* Sars (1896).  
Terminal exopod segments of female fifth legs  
with three spines ... .. 2  
Terminal exopod segments of female fifth legs  
with five or six spines ... .. 11  
Terminal exopod segments of female fifth legs  
with seven spines or setae ... .. 12
2. Right endopod of male fifth leg one-segmented 3  
Right endopod of male fifth leg two-segmented 4  
Right endopod of male fifth leg three-segmented 5
3. First antennae reach to second abdominal seg-  
ment; right endopod of male fifth leg very  
short, digitate ... .. *gracilis* Daday (1902).  
First antennae reach to end of furca; right endo-  
pod of male fifth leg equals the first two exo-  
pod segments, is pointed and curved inwards *occidentalis* Marsh (1906).
4. First antennae reach to end of furca; last thoracic  
segment of female is slightly produced; left  
endopod of male fifth legs one-segmented ... *gracilipes* Daday (1901).  
First antennae reach the end of the furcal setae;  
thoracic processes of female reach the end of  
the first abdominal segment; left fifth endo-  
pod of male two-segmented ... .. *poopoensis* Marsh (1906).
5. Thoracic processes in female very asymmetrical,  
the right one reaching to end of genital seg-  
ment, the left reaching to half way down the  
second abdominal segment ... .. *rahmi* Brehm (1935).  
Thoracic processes in female extend to an equal  
distance left and right ... .. 6
6. Thoracic processes reach less than half the length  
of the genital segment ... .. 7  
Thoracic processes as long or longer than the  
genital segment ... .. 8
7. First antennae of female do not reach the second  
abdominal segment; terminal spine of male  
right fifth leg sickle-shaped ... .. *meteoris* Kiefer (1927).  
First antennae of female extend to or beyond the  
furca; terminal spine of male right fifth leg  
but slightly curved ... .. *michaelseni* Mrazek (1901).



8. Inner margin of second segment of male right fifth leg concave ; thoracic processes reach the end of the genital segment ... .. *dentifera* Brehm (1935).  
The inner margin of this segment convex ; thoracic processes reach to the second or third abdominal segment ... .. 9
9. Inner margin of this segment with a hooked knob *bergi* var. *cornuta* Brehm (1937).  
Inner margin smooth ... .. 10
10. Second basal segment of male left fifth leg bears a sharply triangular serrate lamella at its inner distal corner ... .. *bergi* var. *serrifera* Brehm (1937).  
The corner of this segment smooth ... .. *bergi* Richard (1897).
11. First antennae reach to half the length of the furcal setae ; right fifth endopod of male one-segmented ... .. *insignis* Smith (1909).  
First antennae reach to half the length of the genital segment ; right fifth endopod of male two-segmented ... .. *opauqua* n. sp.  
First antennae reach to the furca ; right fifth endopod of male is three-segmented ... .. *Hemiboeckella searli* Sars (1912).
12. Right endopod of male fifth leg one-segmented 13  
Right endopod of male fifth leg two-segmented 22  
Right endopod of male fifth leg three-segmented 23
13. Inner margin of second basal segment of left fifth leg of male serrate ; but with no lamella ; the left endopod irregularly curved ... .. *coronaria* Henry (1922).  
Inner margin of this segment with a rather prominent serrate lamella ... .. 14  
Inner margin of this segment bears a lamella that is not serrate and is about equal in length to the endopod ; endopod of right leg extends beyond the second exopod segment ... .. *ambigua* Percival (1937).  
Inner margin of this segment not serrate and bearing no serrate lamella ... .. 18
14. Left endopod of male fifth leg two-segmented 15  
Left endopod of male fifth leg one-segmented 16
15. Second basal segment of right male fifth leg smoothly rounded ; left endopod reaching half-way up the first exopod segment ; first antennae do not reach the end of the caudal rami ... .. *pellucida* n.sp.  
Second basal segment of right male fifth leg smoothly rounded ; left endopod reaching to the end of the first exopod segment ; first antennae do not reach beyond the end of the caudal rami ... .. *lacuna* n.sp.  
Second basal segment of right male fifth leg produced into a triangular process ; first antennae extend beyond the caudal rami by at least two segments ... .. *fluvialis* Henry (1922).
16. Terminal spine of right male fifth leg sickle-shaped ; left inner lobe of thoracic processes acute, right one rounded ... .. *orientalis* Sars (1903).  
Terminal spine of right male fifth leg broad in its basal half and abruptly narrowed at about the mid point ; both inner lobes of thoracic processes acute, the outer lobes reaching to the anal opening ... .. *triarticulata* var. *quarta* Brehm (1939).

- Terminal spine of right male fifth leg but slightly curved and tapering evenly ; both inner thoracic lobes acute, not reaching to the anal opening ... .. 17
17. Thoracic processes do not reach the end of the genital segment ; right endopod of male fifth leg reaches the end of the second exopod segment ... .. *triarticulata* var. *oblonga* Brehm (1939)
- Thoracic processes reach the end of the genital segment ; right endopod of male fifth leg does not reach the end of the second exopod segment ... .. *triarticulata* Thompson (1883).
- Thoracic processes reach beyond the genital segment ; right endopod of male fifth leg reaches the end of the second exopod segment ... .. *triarticulata* var. *sarsi* Brehm (1939).
18. Left endopod of male fifth leg short ... .. 19
- Left endopod of male fifth leg nearly equals the first exopod segment in length ... .. 21
- Left endopod of male fifth leg is wanting ... .. *asymmetrica* Searle (1914).
19. Terminal spine of right male fifth leg stout and suddenly constricted in the last sixth of its length ... .. *hamata* Brehm (1928).
- Terminal spine evenly tapered ... .. 20
20. Right endopod of male fifth leg does not reach halfway up the second exopod segment ; second basal segment of this leg produced at the inner distal corner into an acute spine ... .. *rubra* Smith (1909).
- Right endopod reaches at least two-thirds the length of the second exopod segment, and carries near the base on the inner margin a spine ; second basal segment rounded ... .. *robusta* Sars (1896).
21. First antennae of female reach the furca ; thoracic processes short and turned out ... .. *symmetrica* Sars (1903).
- First antennae of female reach the end of the furca ; thoracic processes turn back and reach one half the length of the genital segment ... .. *tenera* Sars (1912).
22. First antennae of female extend to the furca ; thoracic processes extend half the length of the genital segment ... .. *longiseta* Smith (1909).
- First antennae of female extend to the end of the thorax or second abdominal segment ; thoracic processes extend to the second abdominal segment ; terminal spine of right fifth leg in male is cleft at the tip ... .. *pseudocheles* Searle (1912).
23. Second basal segment of male left fifth leg with serrate lamella extending beyond the tip of the endopod ... .. *delicata* Percival (1937).
- This segment has no lamella ... .. 24
24. Thoracic processes extend nearly to end of furca ... .. *nyoraensis* Searle (1912).
- Thoracic processes do not exceed the third abdominal segment ... .. 25
25. Inner surface of the basal segment of the right male fifth leg with a spine ; left fifth endopod is small and broad, its breadth being to its length as 5 : 6 ... .. *saycei* Sars (1908).
- No spine on the basal segment of the right fifth leg ; the left endopod is small and narrow, its breadth being to its length as 3 : 5 ... .. *propinqua* Sars (1904).



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#### EXPLANATION OF PLATES.

##### PLATE I. *Boeckella opaquæ*, n.sp.

- Fig. 1. First antenna of male.
- Fig. 2. Second antenna.
- Fig. 3. Mandible.
- Fig. 4. First maxilla.
- Fig. 5. Second maxilla.
- Fig. 6. Maxilliped.





PLATE II. *Boeckella opaquua* n.sp.

Fig. 1. Female.

Fig. 2. Fifth thoracic and first abdominal segments of female, from the left.

Fig. 3. Abdomen of female, dorsal.

Fig. 4. Abdomen of male, lateral.

Fig. 5. Abdomen of male, dorsal.

Figs. 6-10. Female, legs 1-5.

Figs. 11 and 12. Female, terminal exopod segment of fifth leg.

Figs. 13-15. Female, endopod of fifth leg.

Fig. 16. Male, fifth leg.



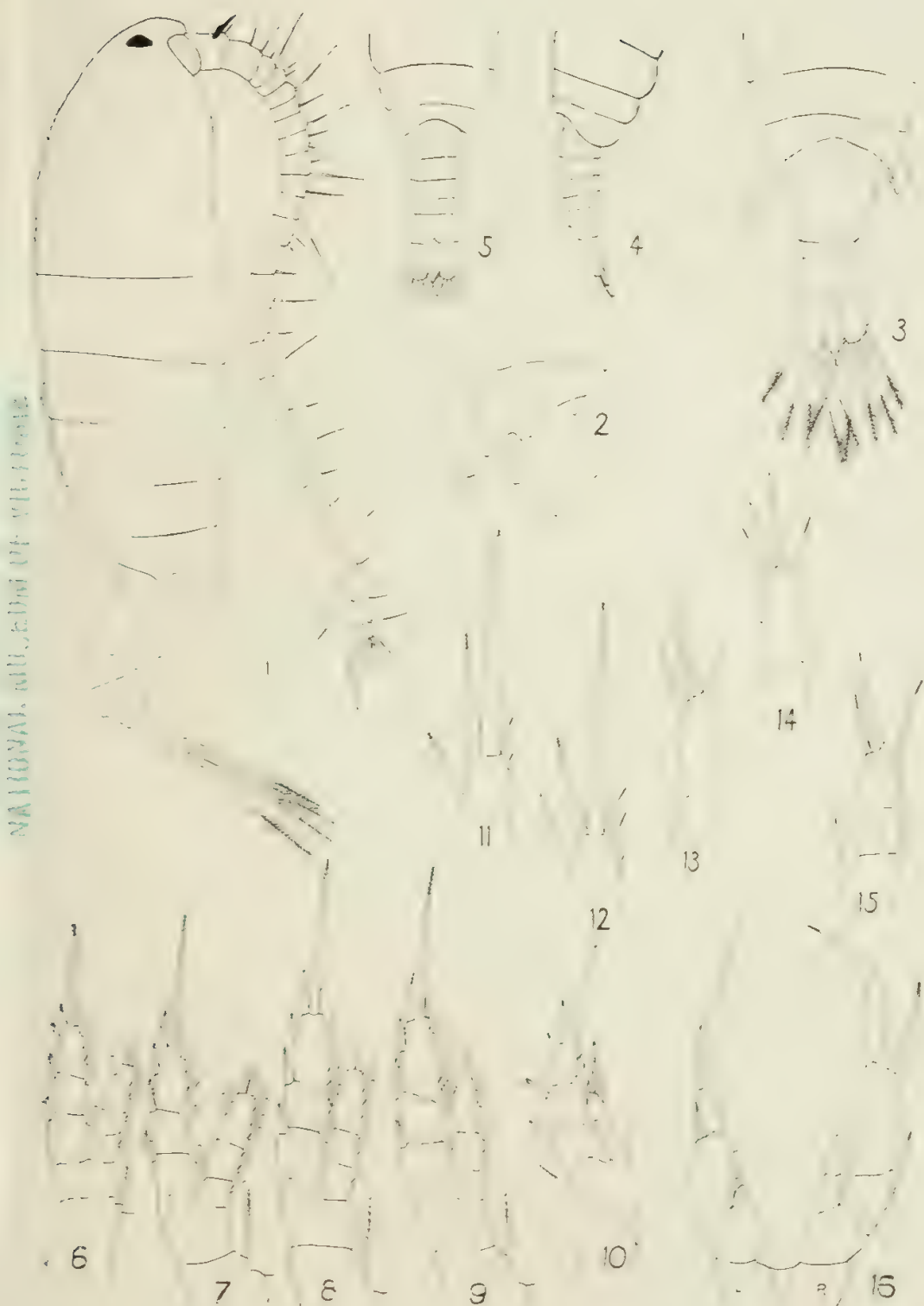


PLATE III. *Boeckella opaqua* n.sp.

Figs. 1-6. Nauplius stages I.-VI., lateral.



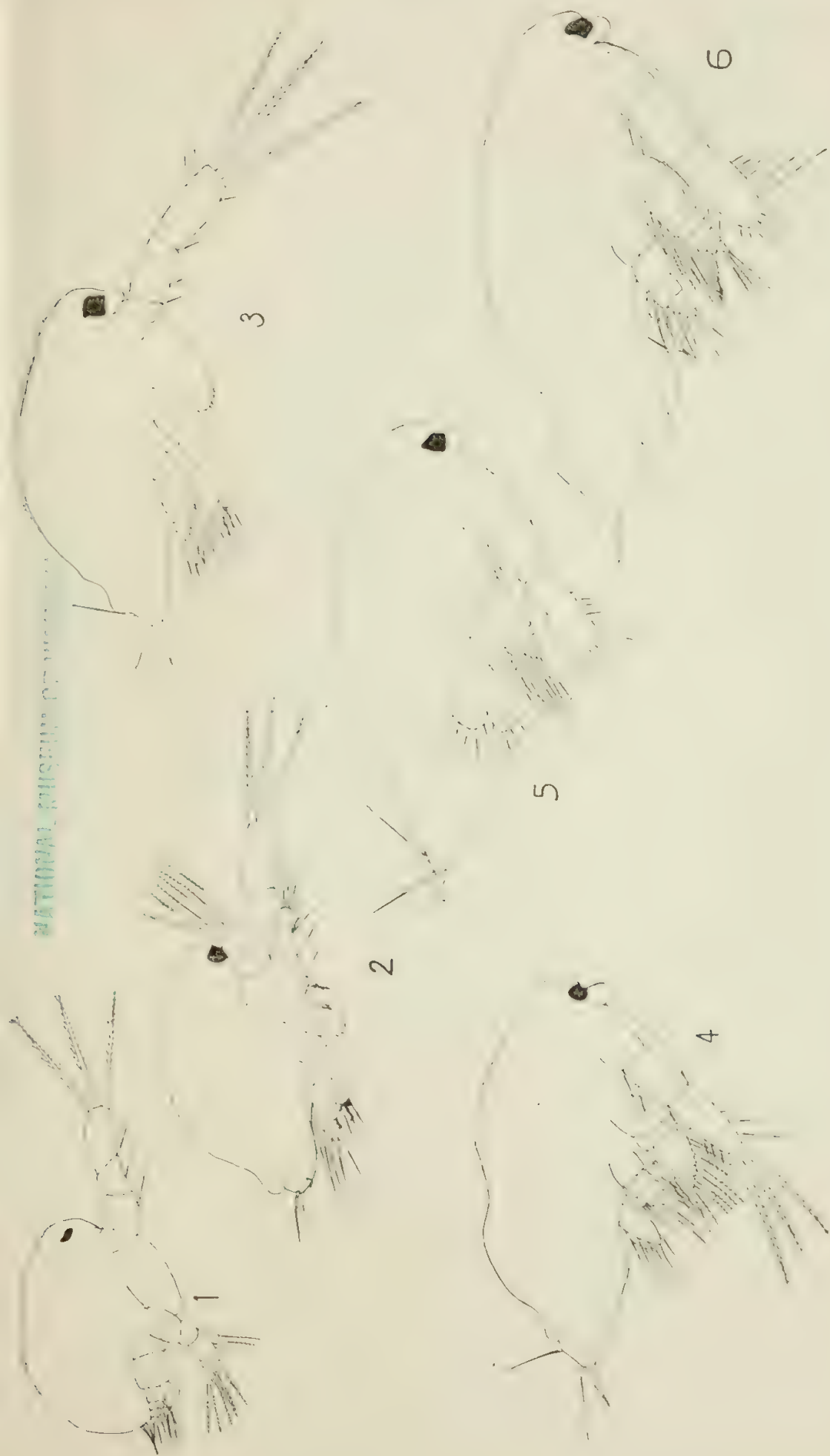


PLATE IV. *Boeckella opaqua* n.sp.

Figs. 1-6. First antenna of nauplius stages I.-VI.

Figs. 7-12. Nauplius stages I.-VI., ventral.



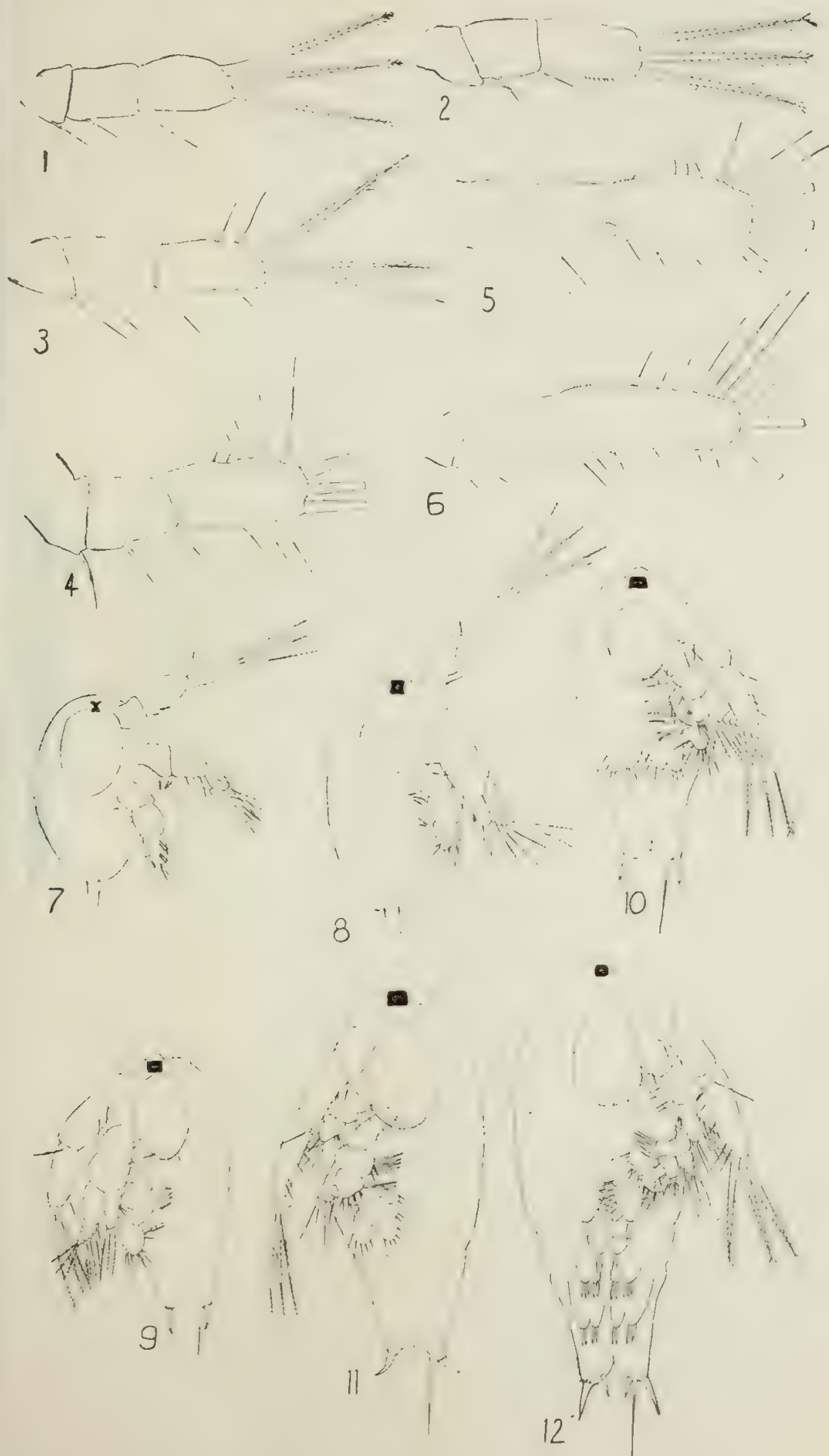


PLATE V. *Boeckella opaquia* n.sp.

Figs. 1-6. Second antenna of nauplius stages I.-VI.

Figs. 7-12. Mandible of nauplius stages I.-VI.

Figs. 13-15. First maxilla of nauplius stages IV.-VI.

Figs. 16. Second maxilla of nauplius stage VI.

Fig. 17. Maxilliped of nauplius stage VI.

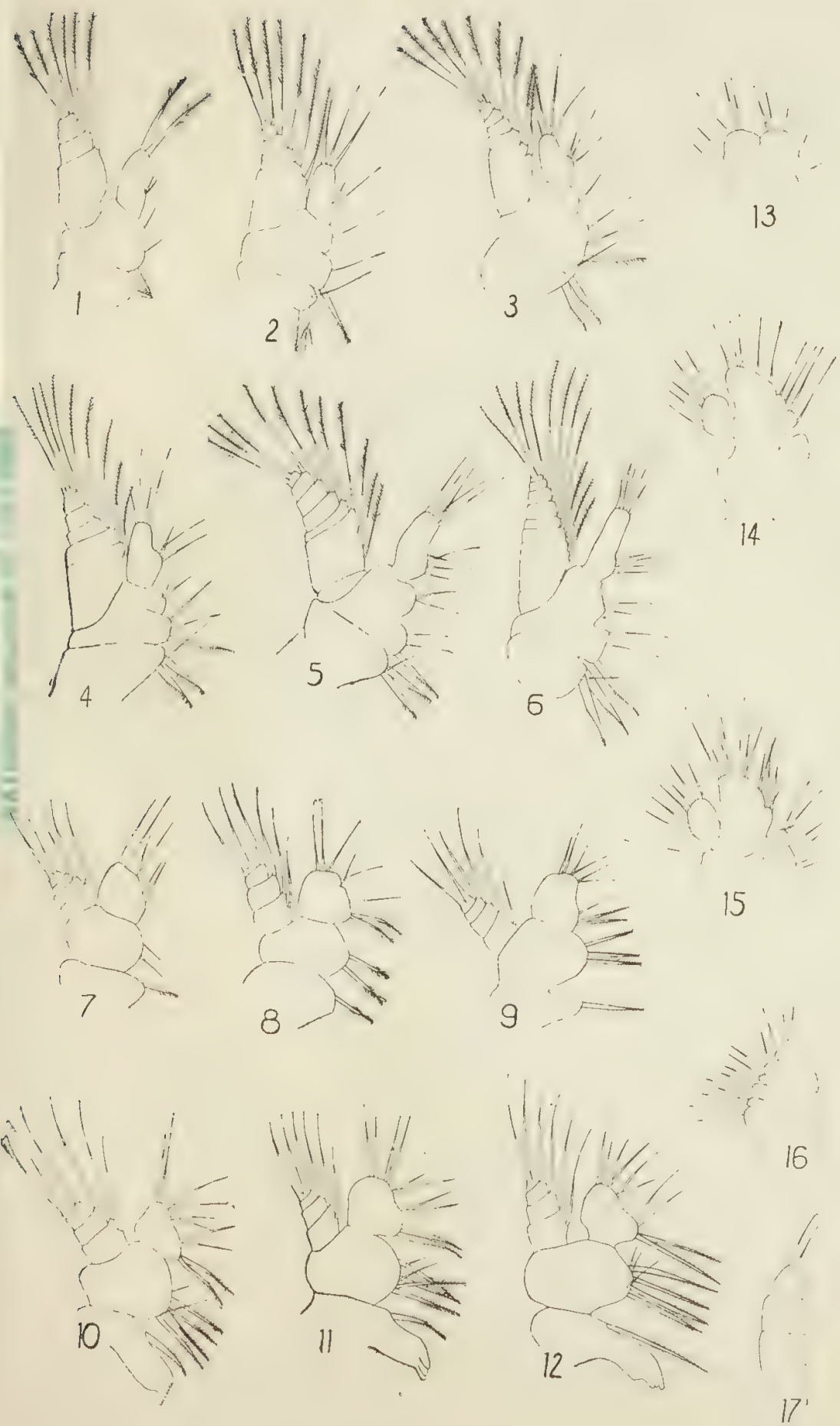




PLATE VI. *Boeckella opaqua* n.sp.

Figs. 1-4. First antenna of copepodid stages I., II., IV., and V. (male).

Figs. 5 and 6. Second antenna of copepodid stages I. and II.

Figs. 7 and 8. Mandible of copepodid stages I. and II.

Figs. 9 and 10. First maxilla of copepodid stages I. and II.

Fig. 11. Second maxilla of copepodid stage I.

Figs. 12 and 13. Maxilliped of copepodid stages I. and II.



PLATE VII. *Boeckella opaquia* n.sp.

Figs. 1 and 2. Swimming legs of copepodid stage I.

Figs. 3-5. Swimming legs of copepodid stage II.

Figs. 6-9. Swimming legs of copepodid stage III.

Figs. 10-13. Swimming legs of copepodid stage IV.

Figs. 14-17. Swimming legs of copepodid stage V.

Figs. 18 and 19. Fifth leg of copepodid stages IV. and V.



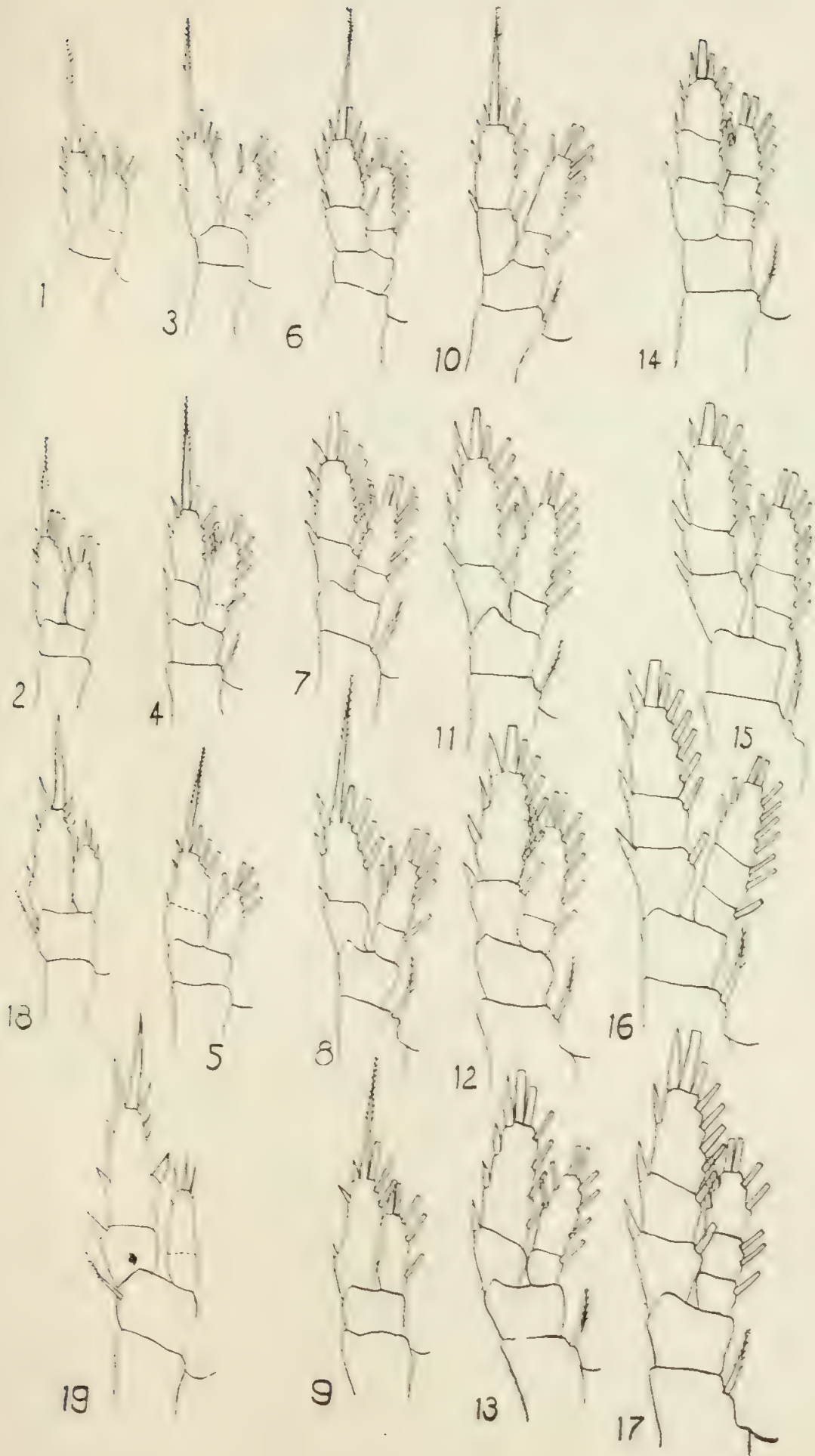


PLATE VIII. *Boeckella opaquæ* n.sp.

Figs. 1-5. Copepodid stages I.-V., dorsal.

Fig. 6. Abdomen and last thoracic segment of female copepodid stage V., lateral.

Fig. 7. Abdomen and last thoracic segment of male copepodid stage V., dorsal.

Figs. 8 and 9. Fifth legs of male copepodid stages V. and IV.

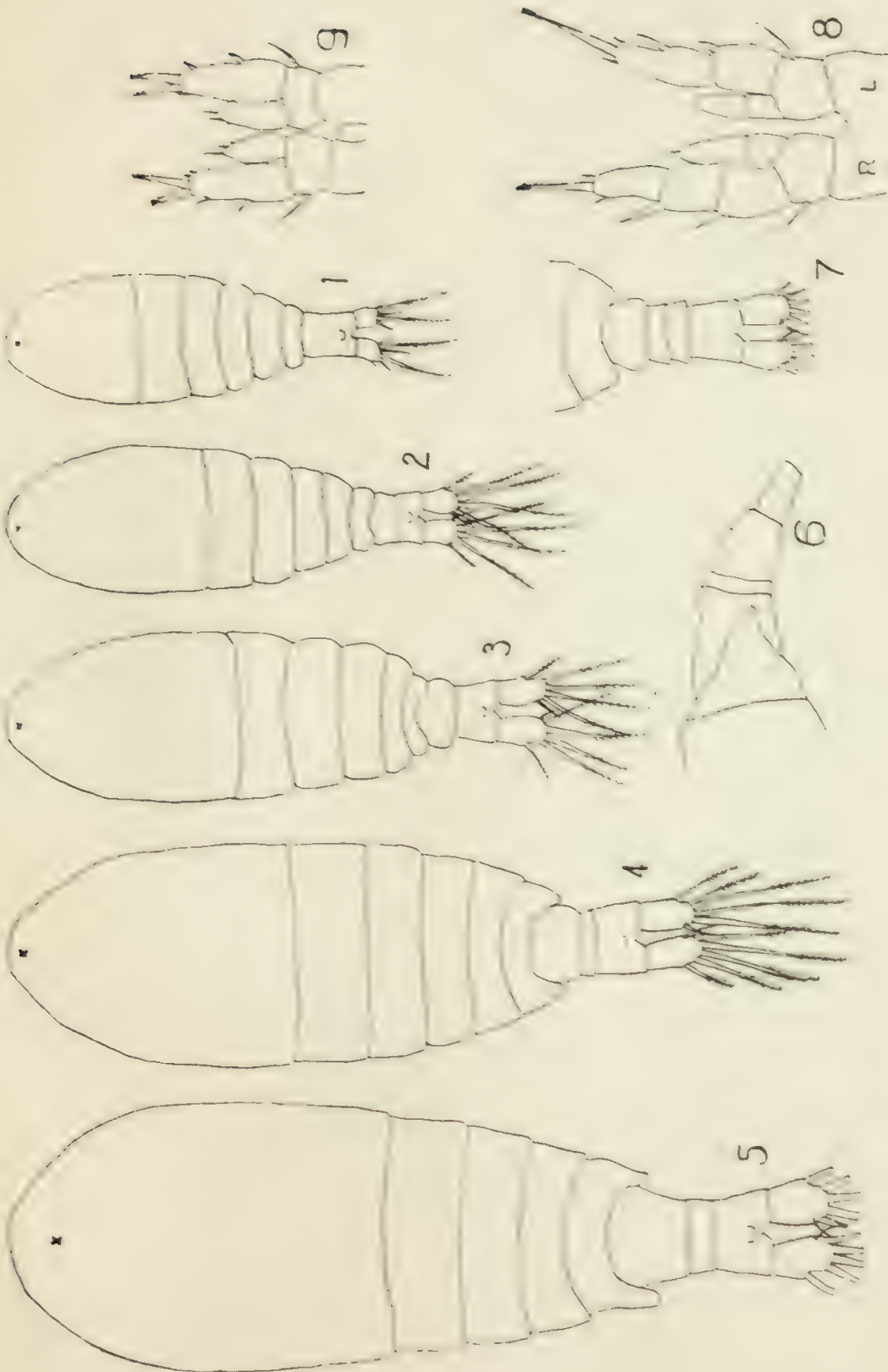




PLATE IX. *Boeckella pellucida* n.sp.

- Fig. 1. First antenna, male.
- Fig. 2. Female, dorsal.
- Fig. 3. Abdomen and last thoracic segment of female, lateral.
- Fig. 4. Abdomen and last thoracic segment of male, dorsal.
- Fig. 5. Abdomen and last thoracic segment of male, lateral.
- Fig. 6. Fifth leg, female.
- Fig. 7. Fifth legs, male.

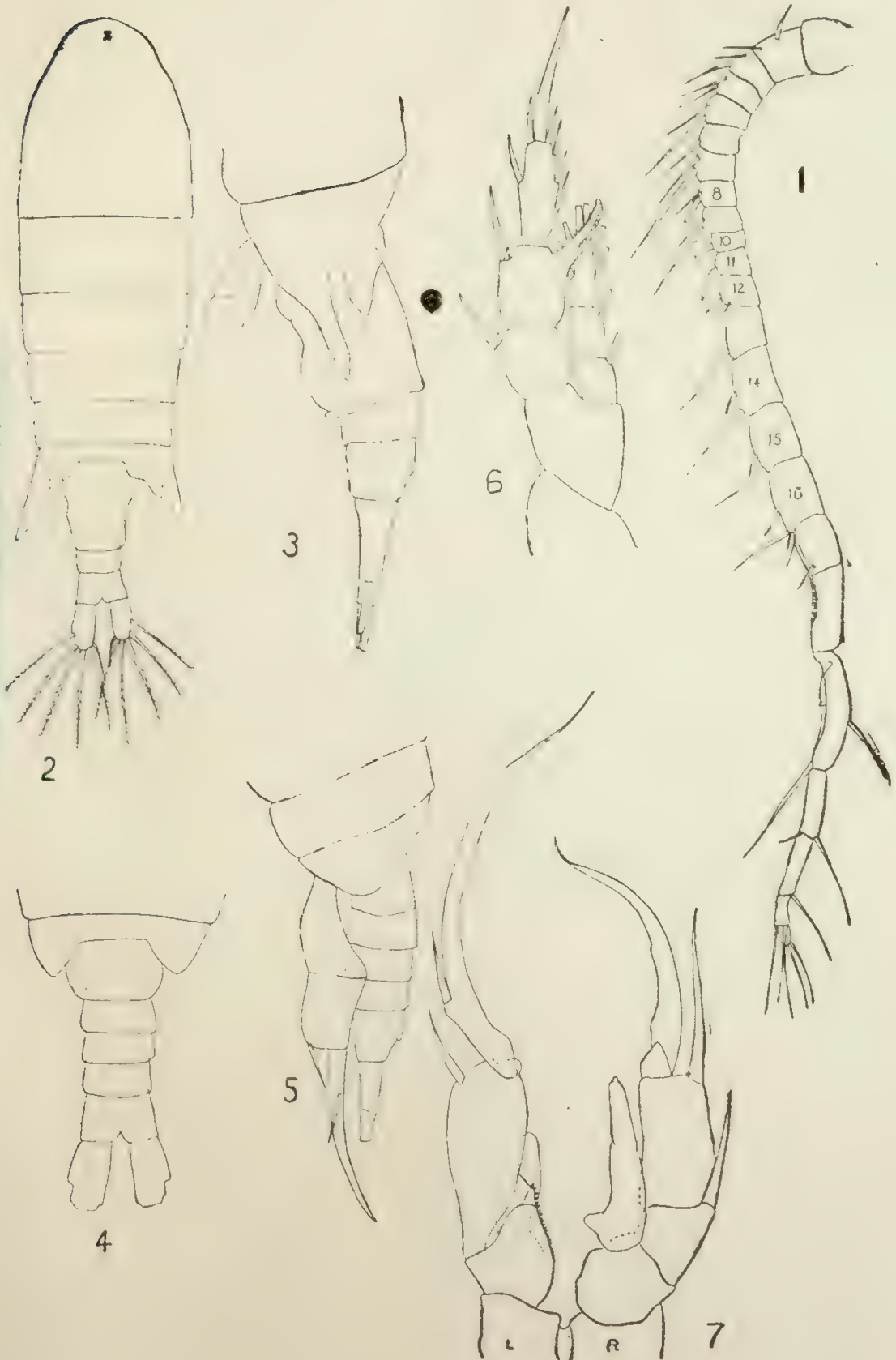
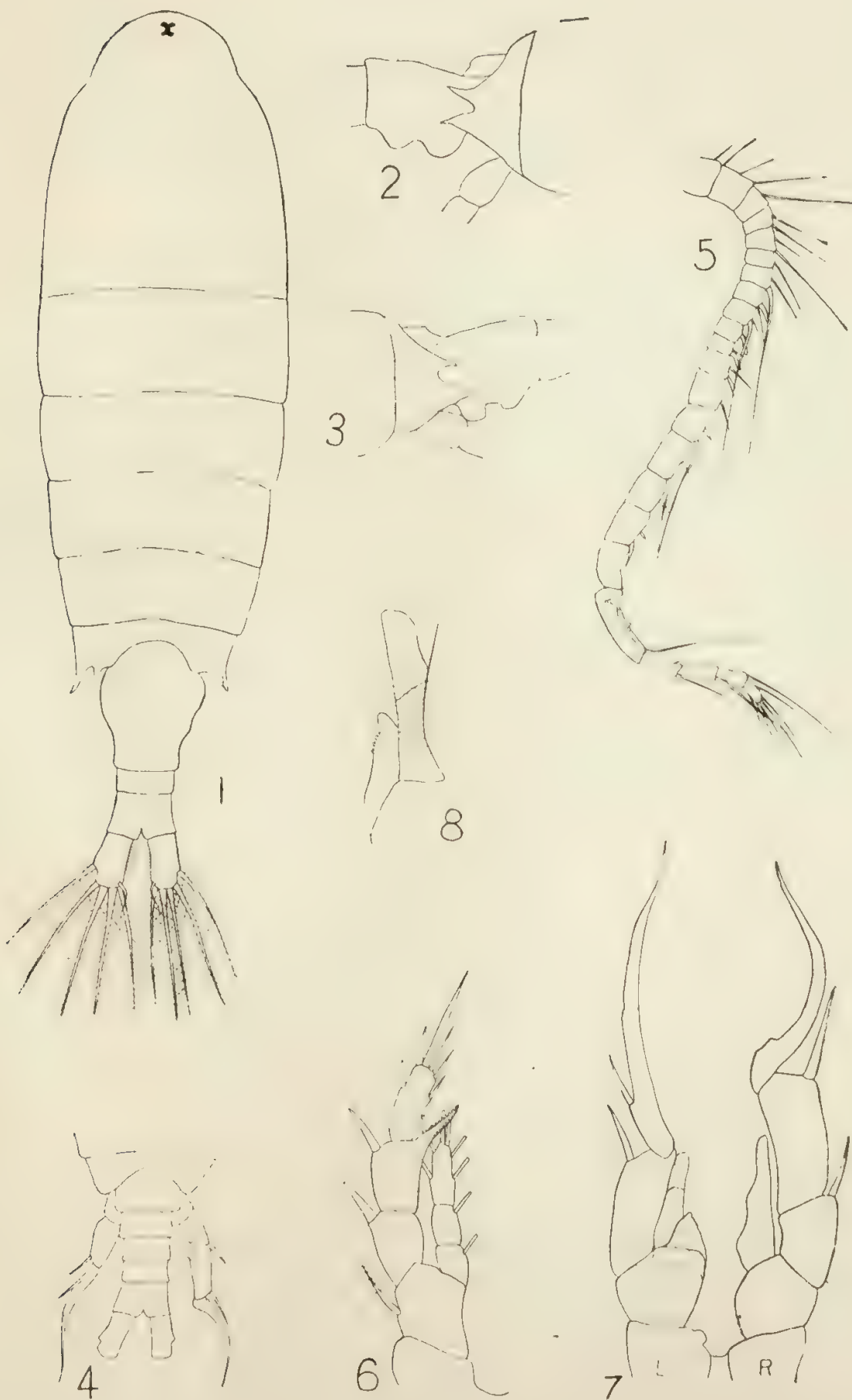


PLATE X. *Boeckella lacuna* n.sp.

- Fig. 1. Female dorsal.
- Fig. 2. Fifth thoracic and first abdominal segments of female, from the right.
- Fig. 3. Fifth thoracic and first abdominal segments of female, from the left.
- Fig. 4. Fifth thoracic segment and abdomen of male, dorsal.
- Fig. 5. First antenna of male.
- Fig. 6. Female, fifth leg.
- Fig. 7. Male, fifth legs, anterior view.
- Fig. 8. Male, fifth leg, left endopod, and second basipod lamella posterior view







#### 4.—WEST AUSTRALIAN FRESHWATER CALANOIDS (COPEPODA).

##### II.—TWO NEW SPECIES OF *BRUNELLA*, WITH AN ACCOUNT OF THE DEVELOPMENTAL STAGES OF *B. SUBATTENUATA* n. sp.

By W. S. FAIRBRIDGE, B.Sc.

Read 10th November, 1942.

##### INTRODUCTION.

Smith (1909, p. 87) proposed the genus *Brunella* for a freshwater Copepod from Tasmania and gave a list of generic features. The species described in the present paper bring the total number of species of *Brunella* so far discovered to nine, all of them freshwater and found in New Zealand, Tasmania, Victoria, and now the South-West of Australia; in addition, Dr. A. G. Nicholls has kindly shown me an unpublished description of a new species of *Brunella* taken in a salt lake in South Australia. In the light of this material, some modification of Smith's original definition of the genus seems desirable. The following definition is therefore proposed:—

Centropagidae with the segmentation of the endopods of the swimming legs reduced, the first being unsegmented, the second, third, and fourth two-segmented; the fifth exopods in the female are typical for the family; in the male the terminal segment of the left fifth exopod is comparatively short and flattened, that on the right is elongated to form part of a long hook; the head is separate from the thorax which is fully segmented, and whose posterior corners may be rounded or produced into acute processes; the female abdomen is three-segmented and bears a very prominent ventral bulge on the genital segment.

##### DESCRIPTION OF NEW SPECIES.

###### Order CALANOIDA.

###### Family CENTROPAGIDAE Sars, 1902.

###### Genus *BRUNELLA* Smith, 1909.

###### *Brunella attenuata* n. sp.

###### LOCALITIES.

1. An artificial concrete pond in the University Quad. (Winter).
2. A perennial natural pond, thickly overgrown with weeds, in the University grounds (Winter).
3. A reedy swamp one to two acres in extent and two to three feet deep, surrounded by paperbark trees, 20 miles along the road between Albany and the Porongorups; probably dry in Summer (Spring).

In all these localities it was found in association with *B. subattenuata* n. sp.



## COLOUR.

The extent and intensity of colour is very variable within a local colony, and those specimens from locality 3 were much darker than ones from clearer water. Eyespot red, thoracic rings and bases of legs blue, mouthparts and genital swelling reddish-brown, rest of the body hyaline. Ova greenish-blue and red.

## FEMALE.

Size : 1.48 to 1.65 mm.

Head, which has a nuchal groove, distinct from the five thoracic segments, the last of which has rounded posterior corners and two patches of minute spinules on either side, one postero-dorsal, the other postero-lateral. Rostrum very short, bifid, and hyaline. Thorax 2.5 times as long as wide. Abdomen three-segmented, the genital swelling being very large and smoothly rounded. Caudal rami somewhat longer than the anal segment and little more than three times as long as wide (as measured at their base).

Mouthparts : First antenna, 25-segmented, extending beyond the caudal rami by one to five segments. Rami of second antenna subequal in length. Mandibular blade large in comparison with palp, and the exopod small (though neither of these features is so marked as in *B. subattenuata* n. sp.). The other mouthparts agree with those of *B. subattenuata* (Plate II.).

Swimming Legs : Seta formula of first four pairs of legs is as follows :—

				endopod	exopod
p. 1	...	...	...	421	1.1.322.0.1
p. 2	...	...	...	3.422	1.1.421.1.1
p. 3	...	...	...	3.422	1.1.421.1.1
p. 4	...	...	...	3.322	1.1.421.1.1

Fifth leg typical for genus, but in some specimens there was a faint line of segmentation in the proximal endopod segment, making a total of three segments (Plate I., Fig. 7).

Single ovisac containing five to nine eggs.

## MALE.

Size : 1.16 to 1.28 mm.

Head and thorax as in the female, the head with a nuchal groove, but the posterior thoracic segment bears only the postero-dorsal patch of spinules. Rostrum longer than in female and curved. Head and thorax 2.8 times as long as wide, and the ratio of abdomen to head and thorax is 1.0 : 2.2 ; abdomen five-segmented. Caudal rami longer than anal segment and rather over two and a half times as long as wide.

Right first antenna geniculate, of 22 segments, bearing one spine on segments 8, 10, 11, 17, and 18, and two on segment 19 ; left antenna 25-segmented.

Fifth legs (Plate I., Figs. 8 and 9) have an unsegmented left exopod and endopod two-segmented ; the exopod appears to be distally expanded and flattened, one apical corner being turned over as a flap and the other corner serrate ; apically this lamella bears a slender spine. Second basal segment of left leg projects as a more or less bifid process forming a cup in which is inserted the endopod. Right leg typical for the genus, second exopod segment reaching to the base of the caudal rami.

***Brunella subattenuata* n. sp.****LOCALITIES.**

1, 2, and 3 as in the preceding species.

4. A number of ponds in the laterite by the road between Albany and the Porongorups, which would be dry in Summer (Spring).

5. Albany—a pond of discoloured water the colour of tea, and a muddy swamp overgrown with reeds (Spring).

**C'OLOUR.**

Very much like the preceding species and equally variable (the hue of an individual was found to change over a period of a few days). Swimming legs sometimes pink : ova dark green.

**FEMALE.**

Size : 0.92 to 1.28 mm.

Body very much like the preceding species, nuchal groove being present, but spinules on the last thoracic segment wanting. Rostrum small, curved, and bifid. Swelling on genital segment very large and usually somewhat angular. Ratio of abdomen to head and thorax, 1.0 : 1.7. Caudal rami nearly five times as long as wide (as measured at the base).

Mouthparts (Plate II.) : First antenna 25-segmented and extending beyond the caudal rami by three or four segments. Second antenna typical, rami subequal and terminal endopod segment bearing eight lateral and eight terminal setae. Mandible blade very large ; exopod small ; endopod has four setae on first segment and eight on the second ; basis bears three setae. First maxilla consists of the usual lobes ; epipod with nine setae, exopod with seven, endopod showing only a trace of segmentation with 1 + 2 + 5 setae, the first inner lobe with two and the second with four stout setae. Second maxilla has five lobes, each with three setae ; sixth lobe with a single seta, and terminal portion bears four setae. Maxilliped of seven segments ; the first bears four protuberances, the distal of which is greatly developed, and these bear one, two, three, and four setae ; second segment bears three setae ; third has three setae and a papilla bearing two setae : fourth, fifth, and sixth segments bear three, two, and one setae respectively, the sixth bearing an additional seta on the posterior margin ; terminal segment bears four setae.

Seta formula for swimming legs agrees with that for *B. attenuata* n. sp. Fifth legs typical and endopod always two-segmented.

A single ovisac with usually eight to eleven eggs.

**MALE.**

Size : 0.90 to 1.00 mm.

Head and thorax as in female ; caudal rami nearly three times as long as wide. Ratio of abdomen to head and thorax, 1.0 : 2.2.

First antennae very much like those of *B. attenuata* ; the right 22-segmented with a spine on segments 8, 10, and 11, and two on segment 19 ; the left 25-segmented.

Fifth legs resemble those of *B. longicornis* Searle (Plate III., Figs. 9-11). Both rami of left leg two-segmented ; terminal endopod segment with six setae like the right, and terminal exopod segment flattened with one large conical spine and one smaller one ; second basal segment produced at its



corner to form a cup for the insertion of endopod, this projection reaching almost to the end of first exopod segment, and rendering the insertion of endopod considerably distal to that of exopod. Right limb of the usual form.

This species resembles *B. longicornis* Searle (1912), but from Searle's description appears to be distinct in a number of points in the male fifth leg, and also in the length of the female caudal rami.

*Note on the Specimens from Albany.*

These varied from specimens from other localities in the following points :—

1. The majority of females measured 1.37 to 1.46 mm., with only a few as small as 1.2 mm. ; the males were 1.0 mm.
2. The females carried about 50 ova in their ovisacs.
3. The first antennae extended beyond the furcae by only two segments.
4. The female genital segment bore a bulge on the right side at the anterior end (Plate III., Fig. 3).
5. The first exopod segment of the left male fifth leg was broader, nearly as broad as the second exopod segment.

THE DEVELOPMENTAL STAGES OF *BRUNELLA SUBATTENUATA*  
n. sp.

*Method :* The adult Copepods bred freely in a large open porcelain dish in which the water was kept about one inch deep ; from here they could be caught and transferred to petrie dishes and watchglasses, in which filtered pondwater was used. It was found impossible to catch the nauplii individually in even these small vessels, so a number of egg-bearing females were permitted to breed for some time in one vessel, formalin was then added and the nauplii picked out with the aid of a microscope. By this means no stage I. nauplii were found ; to obtain the first stage, 10 egg-bearing females were placed in separate watch-glasses and examined daily with the binocular microscope. Although these eggs were kept for over a month, and their parents were in some cases still alive after this time, none of them hatched. After a fortnight a number of eggs from each batch became clear, the others remaining black and opaque ; within these clear ova there appeared a distinct eyespot, and towards the posterior end blue and red oil globules ; there was never any movement, though some were kept in this condition for three weeks. No description of the first nauplius was therefore possible. This species was found in a number of localities (p. 69) liable to be dry in Summer, and since the breeding work was carried out during October and November it is possible that these were resting-eggs ; in this event, those which became clear were probably fully-developed nauplii in the first stage, as Borutzky (1929) has described for *Canthocamptus arcticus* which in this stage survives cold and dry periods (most of the year) within a thick resting-egg. In two cases female copepods thus isolated in watch-glasses produced two batches of eggs. In all the watch-glasses the egg sac was dropped by the female after a week or a fortnight.

COPULATION.

Copulation was observed in this species. A pair was seen to be swimming round with the male behind and grasping the female abdomen in its geniculate antenna. After a minute or two they settled down. The male flicked its ab-



domen forward two or three times and finally succeeded in swinging it completely forward, and was then seen to be clasping the female abdomen by means of its fifth legs and by twisting its own relatively flexible abdomen partially around that of the female.

Both the species of *Brunella* described in this paper, in contrast to species of *Boeckella* previously worked with, jump about very actively when their water is in the least disturbed.

The ova are greenish black, subspherical, and 0.098 mm. in diameter.

#### THE NAUPLII.

Apart from stage I., the general form of the nauplii is very much like that of *Boeckella opaqua* Fairbridge (1944), which seems in turn to be fairly typical for the Centropagidae. They are colourless and the eyespot is red with a patch of blue in front of it : stage II. is an exception, in that the posterior region of the body is a purplish colour due to red and blue pigmentation, and there is no gut visible owing to the body being rendered opaque by the presence of oil globules. All measurements exclude the caudal spines and setae.

#### *Nauplius II.*

Body : 0.148 and 0.156 mm. (Plate IV., Figs. 1 and 2).

Rather squat in side view with labrum tucked under ; caudal region bears two subequal setae. Labrum smooth ; distinct rostral prominence.

First antenna (Plate IV., Fig. 7) : Three-segmented ; the first with one, the second with two, and the third with two apical and one subapical setae ; third segment bears also some hairs on the dorsal margin.

Second antenna (Plate V., Fig. 1) : Coxa with one seta and a strong masticatory hook ; basis with three setae, the proximal of which is strong and plumose ; endopod with two setae laterally and three apically ; exopod of five segments, the first and last bearing two setae, and the others one each.

Mandible (Plate V., Fig. 6) : Coxa produced somewhat on the inner margin, but not toothed, with a strong plumose seta ; basis with two such setae ; endopod with a total of eight setae, the three proximal ones strong and plumose ; exopod of four segments, each with one seta save the fourth, which has two.

#### *Nauplius III.*

Body : Length 0.164 mm. (average of 11 specimens).

After stage II. the body becomes gradually more elongate, and the labrum projects more : the caudal region is cleft forming two lobes, the left of which is slightly the larger throughout the subsequent nauplii : these caudal lobes bear each a stout spine and a slender seta, the right seta being carried usually reflexed forwards along the back : the labrum is smooth in stage III.

First antenna (Plate IV., Fig. 8) : First two segments as in stage II. Third segment bears three setae apically, two only of which are stout and plumose ; ventral margin with one seta, and dorsal with two, one of which is plumose and almost as big as the two strong apical setae.

Second antenna (Plate V., Fig. 2) : Coxa with two masticatory hooks and one seta ; basis with one masticatory hook and three setae ; endopod with three setae laterally and four apical : exopod as in stage II., but terminal segment with three setae.

Mandible (Plate V., Fig. 7) : Coxa with one stout plumose seta ; basis with three such setae and one normal one ; endopod and exopod as in stage II., though the plumose setae appear somewhat stronger.

First maxilla : Present as a distinct lobe.

#### *Nauplius IV.*

Body : Length 0.195 mm. (average of eight specimens).

Labrum hairy at tip. The general form agrees with that of stage V. (Plate IV., Figs. 3 and 4).

First antenna (Plate IV., Fig. 9) : As in stage III., but third segment with three setae on ventral margin and four on dorsal, the third and fourth of which are strong and plumose.

Second antenna (Plate V., Fig. 3) : As in stage III., but basis with one masticatory hook and four setae.

Mandible (Plate V., Fig. 8) : Coxa produced into a toothed chewing process bearing one stout plumose seta ; basis bears four such setae and one normal seta ; endopod produced inwards somewhat at the base and carries a total of ten setae, four of which are apical, and the three proximal ones are stout and plumose ; proximal segment of exopod bears a small additional seta.

First maxilla : A notched lobe bearing five pairs of setae.

#### *Nauplius V.*

Body : Length 0.218 mm. (average of five specimens).

Labrum hairy at tip. The general form of the nauplius is shown in Plate IV., Figs. 3 and 4.

First antenna (Plate IV., Fig. 10) : As in stage IV., but with four setae on ventral margin and six on dorsal, the distal two of which are plumose.

Second antenna (Plate V., Fig. 4) : As in stage IV., but endopod with four setae laterally and five apical ; exopod of seven segments, the proximal unarmed, the second with two setae, and the apical with three.

Mandible (Plate V., Fig. 9) : As in stage IV.

First maxilla (Plate V., Fig. 11) : Shows an indication of three lobes, exopod bearing three setae, endopod five, and the other lobe two.

#### *Nauplius VI.*

Body : Length 0.253 mm. (average of 11 specimens).

There is an additional spine on each caudal ramus interior to the seta ; the general form is shown in Plate IV., Figs. 5 and 6. Labrum hairy at tip.

First antenna (Plate IV., Fig. 11) : As in stage V., but terminal segment bears five setae on ventral margin and eight on dorsal margin.

Second antenna (Plate V., Fig. 5) : As in stage V., but second exopod segment bears an additional seta.

Mandible (Plate V., Fig. 10) : As in stage V.

First maxilla (Plate V., Fig. 12) : Gnathobase and epipod developed as lobes bearing two minute and one normal seta respectively ; exopod bears three setae, endopod six and the inner lobe two.

Second maxilla : A three-segmented appendage with about fifteen setae on the inner margin, but with only the barest indication of lobes.

Maxilliped : Present as a lobe with two terminal setae, and partial segmentation into three.

First and Second swimming legs : Rudimentary.

TABLE I.—The Naupliar Appendages.

First antenna.

Stage.						1st Segment.	2nd Segment.	3rd Segment.
II.	...	...	...	...	...	S	2S	3p
III.	...	...	...	...	...	S	2S	3p 3S
IV.	...	...	...	...	...	S	2S	4p 6S
V.	...	...	...	...	...	S	2S	4p 9S
VI.	...	...	...	...	...	S	2S	4p 12S

Second antenna.

Stage.						Coxa.	Basis.	Endopod.	Exopod.
II.	...	...	...	...	...	MS	F2S	2S 3Sp	2p.p.p.p.2p
III.	...	...	...	...	...	2MS	M3S	3S 3Sp	2p.p.p.p.3p
IV.	...	...	...	...	...	2MS	M4S	3S 3Sp	2p.p.p.p.3p
V.	...	...	...	...	...	2MS	M4S	4S 4Sp	0.2p.p.p.p.p.3p
VI.	...	...	...	...	...	2MS	M4S	4S 4Sp	0.3p.p.p.p.p.3p

Mandible.

Stage.						Coxa.	Basis.	Endopod.	Exopod.
II.	...	...	...	...	...	F	2F	3F 5S	S.S.S.2S
III.	...	...	...	...	...	F	3FS	3F 5S	S.S.S.2S
IV.	...	...	...	...	...	BF	4FS	3F 7S	2S.S.S.2S
V.	...	...	...	...	...	BF	4FS	3F 7S	2S.S.S.2S
VI.	...	...	...	...	...	BF	4FS	3F 7S	2S.S.S.2S

S = Seta.  
p = Plumose seta.  
F = Plumose seta modified for feeding.

M = Masticatory hook.  
B = Toothed mandibular blade.

THE COPEPODIDS.

The copepodid stages are quite typical : the second antenna, mandible, and first and second maxilla bearing all the main adult features in the first stage, and in later stages showing an increase only in the number of setae, the second antenna and mandible altering in the endopods only. The first antenna and maxilliped on the other hand show an increase in segmentation as well as in armature up to the adult condition.

The setation and segmentation of the swimming legs is shown in tabular form on p. 76. Table II.

All measurements were made to the end of the caudal rami.



*Copepodid I.*

Size : 0.38 mm. (average of two specimens).

Thorax five-segmented ; abdomen (Plate VI., Fig. 1) one-segmented ; the caudal setae not fully developed, inner seta wanting and two of the apical setae strong, while two but weakly developed.

Mouthparts : First antenna 11-segmented, segments three and four long and showing indications of subdivision. Second antenna (Plate VI., Fig. 2) much less slender than in adult, especially in endopod ; setation of coxa, basis, and exopod agrees with that of adult, while first endopod segment bears a pair of setae, and terminal segment a tuft of three setae laterally and five apically. Blade of mandible (Plate VI., Fig. 3) as in adult, large ; basis bears three setae but is less slender than in later stages ; exopod agrees with adult save for its relatively larger size ; first endopod segment bears three, and terminal five setae. All lobes of first maxilla (Plate VI., Fig. 4) present ; epipod bears four long plumose setae ; exopod three setae ; endopod shows only a trace of segmentation with one seta laterally and four apically ; first and second inner lobes bear four and two setae as in adult ; gnathobase has considerably less teeth than in adult. Second maxilla (Plate VI., Fig. 5) already nearly in adult condition, though segmentation is indistinct and the lobes each bear two setae only. Maxilliped (Plate VI., Fig. 6) four-segmented ; the first showing four protuberances bearing one, one, one and two setae ; second segment bears two setae, the third one, and the fourth four.

Swimming Legs : First two pairs present and third pair indicated by lobes. Both rami of first two pairs of legs unsegmented.

*Copepodid II.*

Size : 0.46 mm. (average of three specimens).

Abdomen incompletely two-segmented and caudal setae in the adult condition.

Mouthparts : First antenna (Plate VI., Fig. 7) is of a possible 17 segments, though four of these divisions are indistinct. Second antenna more elongate than in stage I. (this process of elongation proceeding throughout the copepodids), and terminal endopod segment bears four setae laterally and six apically. Mandible as in stage I. Epipod of first maxilla bears six setae, and the other lobes agree with stage I., and there are more teeth on gnathobase. Basal lobe of second maxilla now bears three setae, but the other lobes only two each. Maxilliped (Plate VI., Fig. 8) five-segmented ; anterior distal corner of basal segment taking on the adult form ; first segment bears one, two, two and three setae on its protuberances, second segment two setae ; the third bears one seta and a proximal papilla with two setae ; the fourth has one seta and the fifth four.

Swimming Legs : Three pairs are present, and the fourth present as buds. Exopods of the first two pairs and endopods of the second pair, two-segmented : the first endopods and both rami of the third pair are unsegmented.

*Copepodid III.*

Size : 0.56 mm. (average of five specimens).

The abdomen is two-segmented.

Mouthparts : First antenna 23-segmented. Second antenna agrees with the adult, save that the terminal endopod segment bears five setae laterally and six apically. Mandible agrees with that of stage II. Epipod of first

maxilla bears eight setae, exopod four; endopod now three-segmented, the segments bearing one, two, and four setae. Second maxilla agrees with stage II. Maxilliped (Plate VI., Fig. 9), is of six segments; the first with one, two, two, and four setae, second segment with two, the third with one seta and two on a papilla, the fourth one, the fifth with one seta on both the anterior and posterior margins, and the sixth with four.

Swimming Legs: Four pairs are present, the fifth are indicated as buds. First endopod unsegmented, exopod three-segmented; second endopod two-segmented, exopod three; both rami of the third pair are two-segmented, and both rami of the fourth pair unsegmented.

#### *Copepodid IV.*

Size: Male, 0.64 mm. (one specimen); female, 0.64 mm. (average of five specimens).

Abdomen in female three-segmented, the division between the first and second segments being indistinct. Male abdomen indistinctly four-segmented, the last being the longest.

Mouthparts: First antennae in both sexes 24-segmented. Second antenna agrees with the adult save that terminal endopod segment bears six setae laterally and six apically. Mandible agrees with the adult save that first endopod segment bears four setae and the apical segment six. First maxilla agrees with stage III., save that exopod bears six setae, and the apical endopod segment five. Second maxilla agrees with the adult. Maxilliped is of six segments, differing from the adult in bearing only two setae on segments three and four, one anterior and one posterior on the fifth, and four setae on the sixth.

Swimming Legs: Five pairs are present, and the segmentation of the first four does not differ from that in the adult. Female fifth legs (Plate VI., Fig. 10) very similar to those of male (Plate VI., Fig. 11) but may be distinguished by the exopod bearing three setae apically instead of two setae and two spines as in the male. Segmentation of exopod is indistinct in the case of the female.

#### *Copepodid V.*

Size: Male, 0.74 mm. (average of seven specimens); female, 0.96 mm. (average of six specimens).

Abdomen of the female (Plate VI., Fig. 12) with a ventral protuberance on the genital segment; male abdomen four-segmented, the last segment being as long as the caudal rami.

Mouthparts: First antennae 25-segmented in both sexes and show no sign of asymmetry or spines. Second antennae are like those of the adult save that terminal endopod segment bears seven setae laterally and seven apically. Mandible agrees with that of stage IV. First and second maxillae agree with the adult, as does also the maxilliped.

Swimming Legs: The segmentation of the first four pairs agrees with the adult. Fifth legs of the female (Plate VI., Fig. 13) show only a slight trace of segmentation in the endopods; inner marginal spine of second exopod segment not fully formed, and terminal exopod segment bears four inner marginal spines and a stouter apical spine as in the adult (in one specimen these inner spines were three in number and reduced in size). In the male (Plate VI., Fig. 14) the fifth endopods show traces of segmentation.

TABLE II.—Armature and Segmentation of Swimming Legs.

*1st Leg.*

Stage.	Coxa.	Basis.	Endopod.		Exopod.	
			Segmenta- tion.	Armature.	Segmenta- tion.	Armature.
I. ...	...	...	1	p2p	1	pppSss
II. ...	...	...	1	ppp2p	2	o.ppppSs.o
III. ...	...	p	1	ppp2pp	3	p.p.pppSs.o.o
IV. ...	...	p	1	pppp2pp	3	p.p.ppppSs.o.o
V. ...	...	p	1	pppp2pp	3	p.p.ppppSs.o.o
Adult ...	...	p	1	pppp2pp	3	p.p.ppppSs.o.o

*2nd Leg.*

Stage.	Coxa.	Basis.	Endopod.		Exopod.	
			Segmenta- tion.	Armature.	Segmenta- tion.	Armature.
I. ...	...	...	1	pp2p	1	ppSs
II. ...	...	p	2	o.pp2pp.o	2	o.ppppSs.s
III. ...	...	p	2	o.pp2pp.o	3	o.p.ppppSs.s.s
IV. ...	...	p	2	pp.ppp2pp.o	3	p.p.ppppSs.s.s
V. ...	...	p	2	ppp.pppp2pp.o	3	p.p.ppppSs.s.s
Adult ...	...	p	2	ppp.pppp2pp.o	3	p.p.ppppSs.s.s

*3rd Leg.*

Stage.	Coxa.	Basis.	Endopod.		Exopod.	
			Segmenta- tion.	Armature.	Segmenta- tion.	Armature.
II. ...	...	...	1	pp2pp	1	pppSs
III. ...	...	p	2	p.ppp2pp.o	2	o.ppppSs.s
IV. ...	...	p	2	pp.ppp2pp.o	3	p.p.ppppSs.s.s
V. ...	...	p	2	ppp.pppp2pp.o	3	p.p.pppppSs.s.s
Adult ...	...	p	2	ppp.pppp2pp.o	3	p.p.pppppSs.s.s

*4th Leg.*

Stage.	Coxa.	Basis.	Endopod.		Exopod.	
			Segmenta- tion.	Armature.	Segmenta- tion.	Armature.
III. ...	...	...	1	pp2p	1	pppSs
IV. ...	...	p	2	pp.pp2pp.o	3	o.p.ppppSs.s.s
V. ...	...	p	2	ppp.ppp2pp.o	3	p.p.pppppSs.s.s
Adult ...	...	p	2	ppp.ppp2pp.o	3	p.p.pppppSs.s.s

p = Seta.

2p = The two apical endopod setae.

s = Outer-edge spine.

S = Apical spine.



## DISCUSSION.

The five nauplius stages described are strikingly similar to those of *Boeckella opaqua* Fairbridge (1944), not only in their general shape, but in the shape and setation of their appendages, even the first antennae agreeing in the number of setae for stages II. to V. and differing in stage VI. only to the extent of one seta. The first antennae do differ, however, in that the three pronounced apical plumose setae of *Boeckella* are represented in the present species by two strong apical plumose setae, and one very much weaker non-plumose seta ; as if to compensate for this reduction of terminal setae, the dorsal subterminal seta is plumose and very stout, and the same applies to a lesser extent to the dorsal one adjacent to it in later stages. The armature of the caudal rami is of the same type in the two species, differing only in the relative stoutness of the spines.

This very strong similarity of the last five nauplius stages of *Brunella* with those of *Boeckella* make it reasonable to suppose that the first nauplius of *Brunella*, when found, will also prove to be like that of *Boeckella*. Lacking any evidence to the contrary, we can in the meantime say that a comparison of the larvae of these two genera demonstrates a very close relationship between them.

In respect of the copepodids, Johnson (1934, p. 480) found that in *Epididocera amphitrites* and also in *Tortanus discaudatus* (Johnson, 1934a), each leg has unsegmented rami at its first appearance, and at the first moult the exopod becomes two-segmented and remains so till stage V., in which it is three-segmented, and the endopods for the first time two-segmented ; in *Centropages* and *Calanus finmarchicus*, however, the endopods being three-segmented in the adult, become two-segmented at the time of the exopods (*i.e.*, at the first moult), and both rami then acquire the adult segmentation in stage V. *Boeckella* follows this latter type, having all its swimming legs fully segmented. But *Brunella*, since the segmentation of the endopods in the adult tends to be suppressed, maintains the juvenile unsegmented first endopod throughout, and the other endopods become two-segmented in their first moult and remain so for the subsequent stages, while the exopods acquire a segment at each of the first two moults, thus attaining the adult condition earlier than in the two types mentioned above (the fourth exopod is an exception in becoming three-segmented at the first moult).

The development of the male fifth legs is quite straightforward ; but they are markedly different in stage V. from those of the female, thus resembling *Boeckella* and differing from *Centropages hamatus* (Gurney, 1931, p. 89 and Fig. 103) in beginning already to take on their highly modified form.

## CONCLUSION.

The freshwater Calanoid fauna of the South-West of this State is recruited from two genera, *Boeckella* and *Brunella*, which seem to have arisen from a common stock. They are both genera in which variability seems to centre in the thoracic wings of the females and in the fifth legs of the males and in little else, the two genera being much alike in nearly all their characters. *Brunella* has developed along the path of reduction of the segmentation of the endopods of the swimming legs and modification of the male left fifth exopod, whereas *Boeckella* exhibits a progressive reduction in the fifth endopods. *Brunella* is confined within an area inside the geographical range of *Boeckella*, and has been found in New Zealand, Tasmania, Victoria, South Australia (*see p.67*), and South-West Australia. The genus seems, therefore, to have spread freely along the lines of latitude, but not in a North-South direction :

the usual explanation for such a distribution is given as that of climate. Incidentally this distribution (this is the first record of *Brunella* from this coast of Australia) is one further link between the fauna of the South-Western coastal area and that of the South-East and Tasmania—regions which have been shown (Nicholls, 1933) to have closer faunistic relations with one another than with the intervening regions.

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#### PLATE I.—*Brunella attenuata* n. sp.

- Fig. 1. Female, lateral.
- Fig. 2. Female abdomen, dorsal.
- Figs. 3 and 4. Male abdomen, dorsal and lateral.
- Fig. 5. Male, right first antenna.
- Fig. 6. First swimming leg.
- Fig. 7. Female, fifth leg.
- Fig. 8. Male left fifth leg, seen from the interior margin.
- Fig. 9. Male fifth pair of legs.

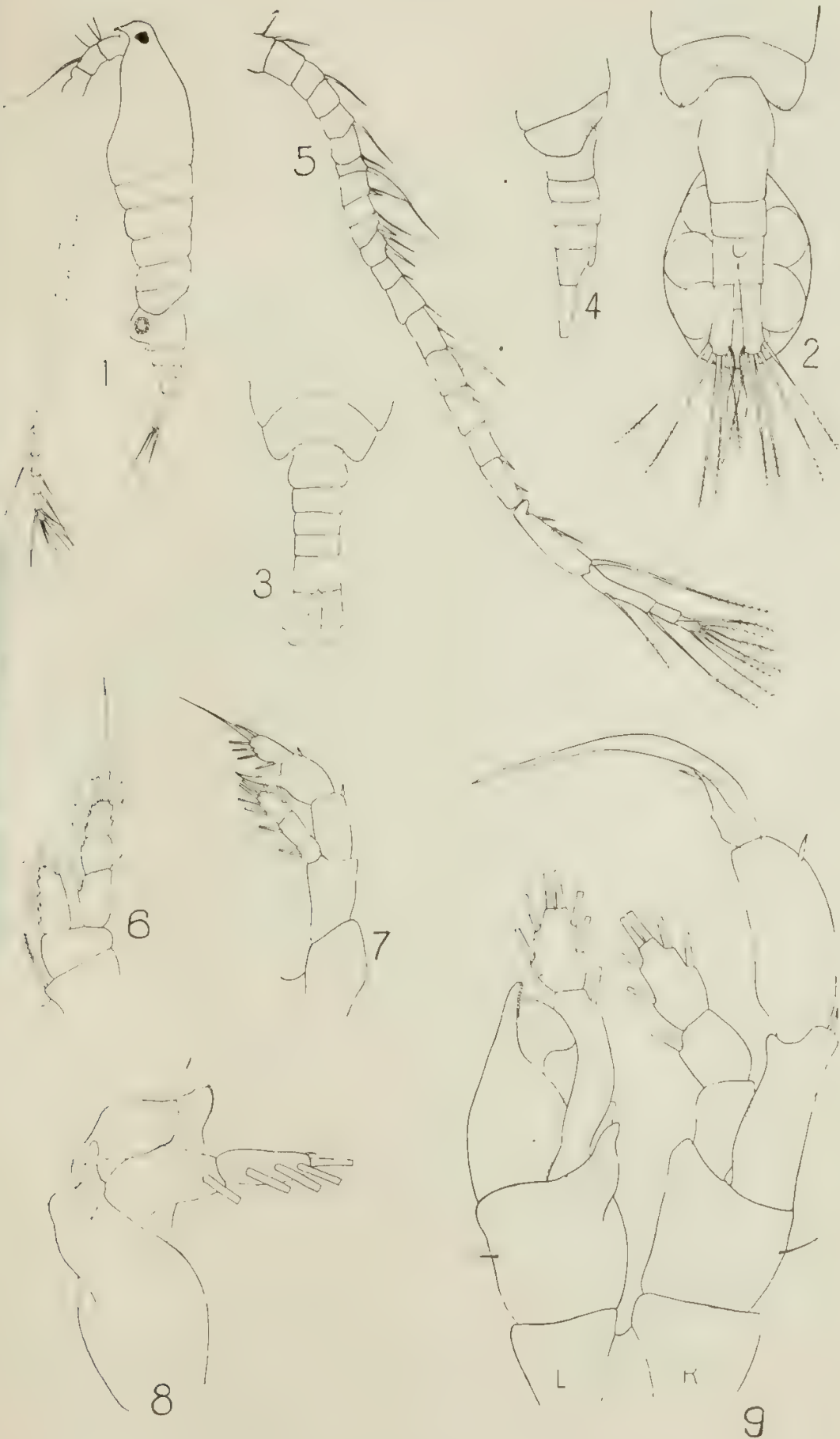


PLATE I.



PLATE II.—*Brunella subattenuata* n. sp.

- Fig. 1. Male, right first antenna.
- Fig. 2. Second antenna.
- Fig. 3. Mandible.
- Fig. 4. First maxilla.
- Fig. 5. Second maxilla.
- Fig. 6. Maxilliped.

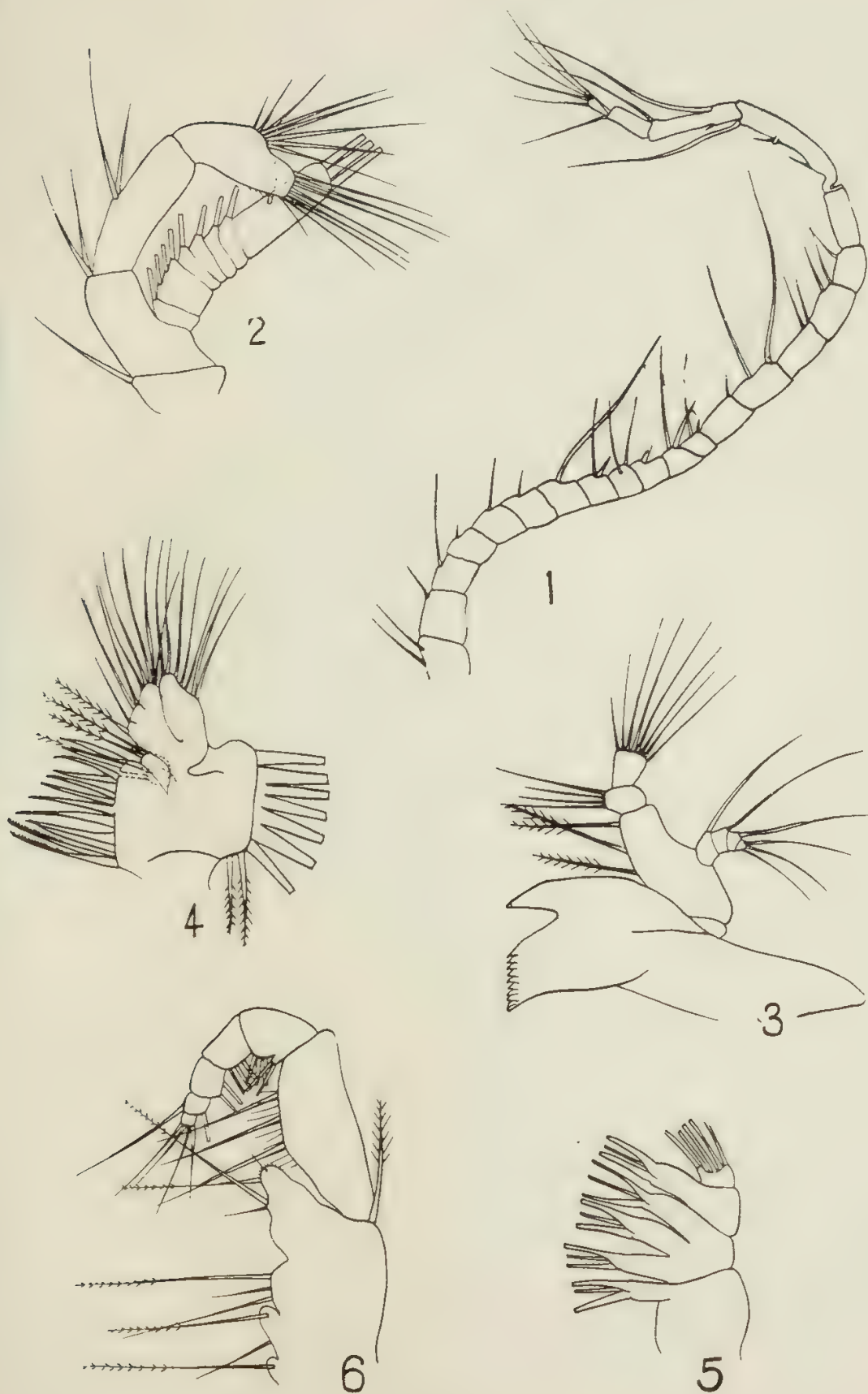


PLATE II.

PLATE III.—*Brunella subattenuata* n. sp.

- Fig. 1. Female, lateral.
- Fig. 2. Female abdomen, dorsal.
- Fig. 3. Female genital segment, dorsal ; specimen from Albany.
- Figs. 4 and 5. Male abdomen, dorsal and lateral.
- Figs. 6 and 7. First and fourth swimming legs.
- Fig. 8. Female fifth leg.
- Fig. 9. Male fifth legs, posterior aspect.
- Fig. 10. Male left fifth leg, from the outer margin.
- Fig. 11. Male right fifth leg, anterior aspect.



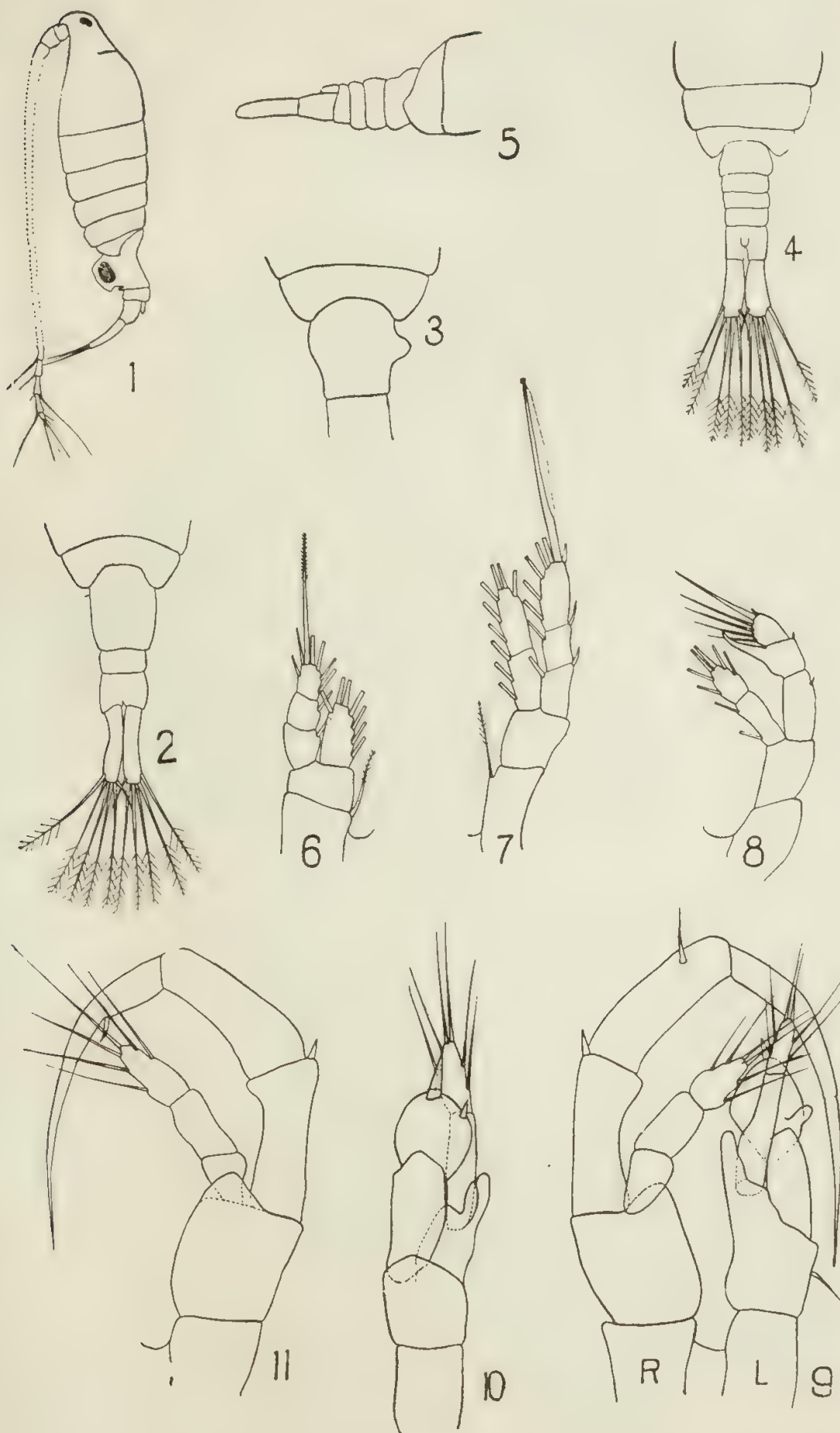


PLATE III.

PLATE IV.—*Brunella subattenuata* n. sp.

- Figs. 1 and 2. Nauplius II., ventral and lateral.  
Figs. 3 and 4. Nauplius V., ventral and lateral.  
Figs. 5 and 6. Nauplius VI., ventral and lateral.  
Figs. 7 to 11. First antenna of Nauplii II.-VI.

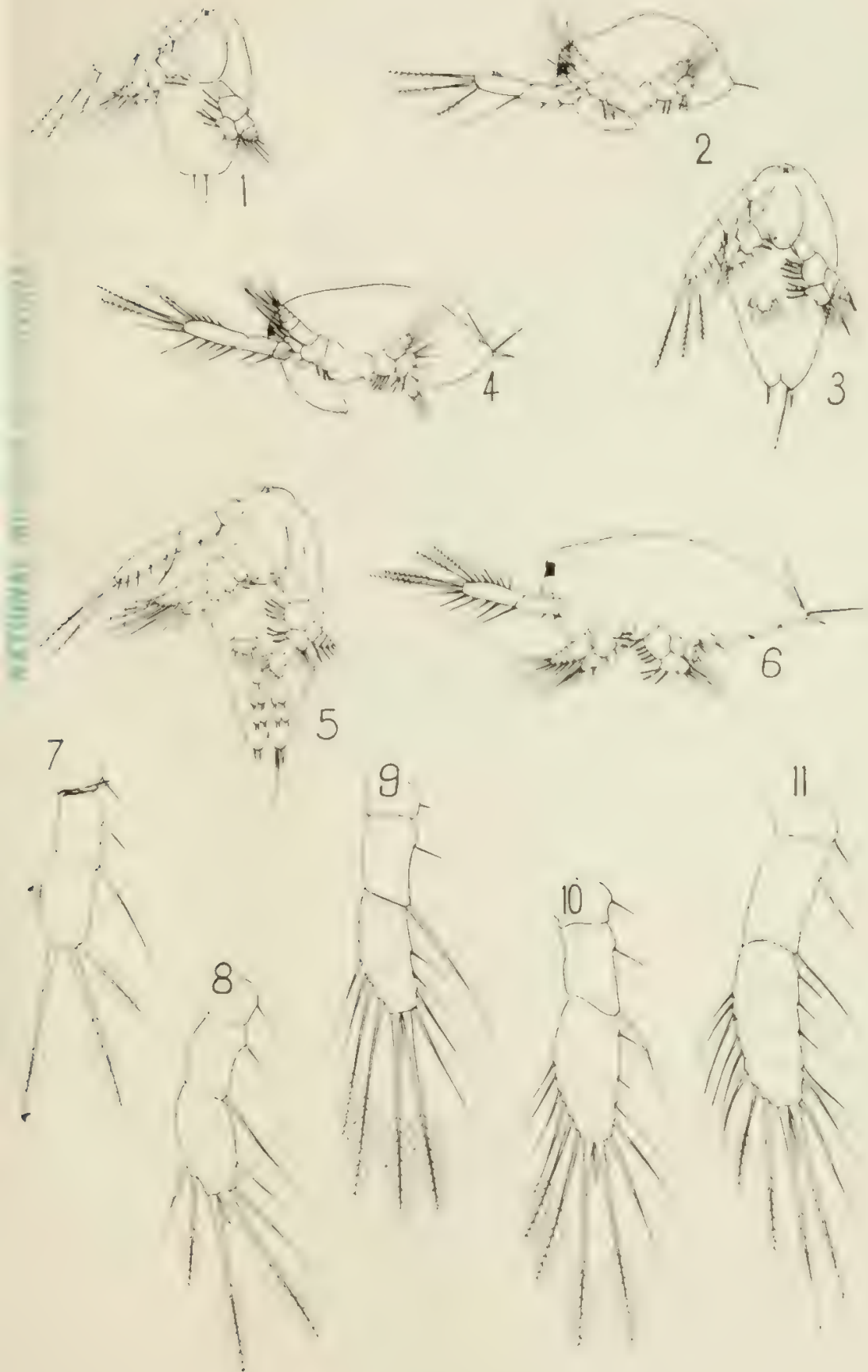


PLATE IV.



PLATE V.—*Bruncella subattenuata* n. sp.

Figs. 1 to 5. Second antenna of Nauplii II.-VI.

Figs. 6 to 10. Mandible of Nauplii II.-VI.

Figs. 11 and 12. First maxilla of Nauplii V. and VI.

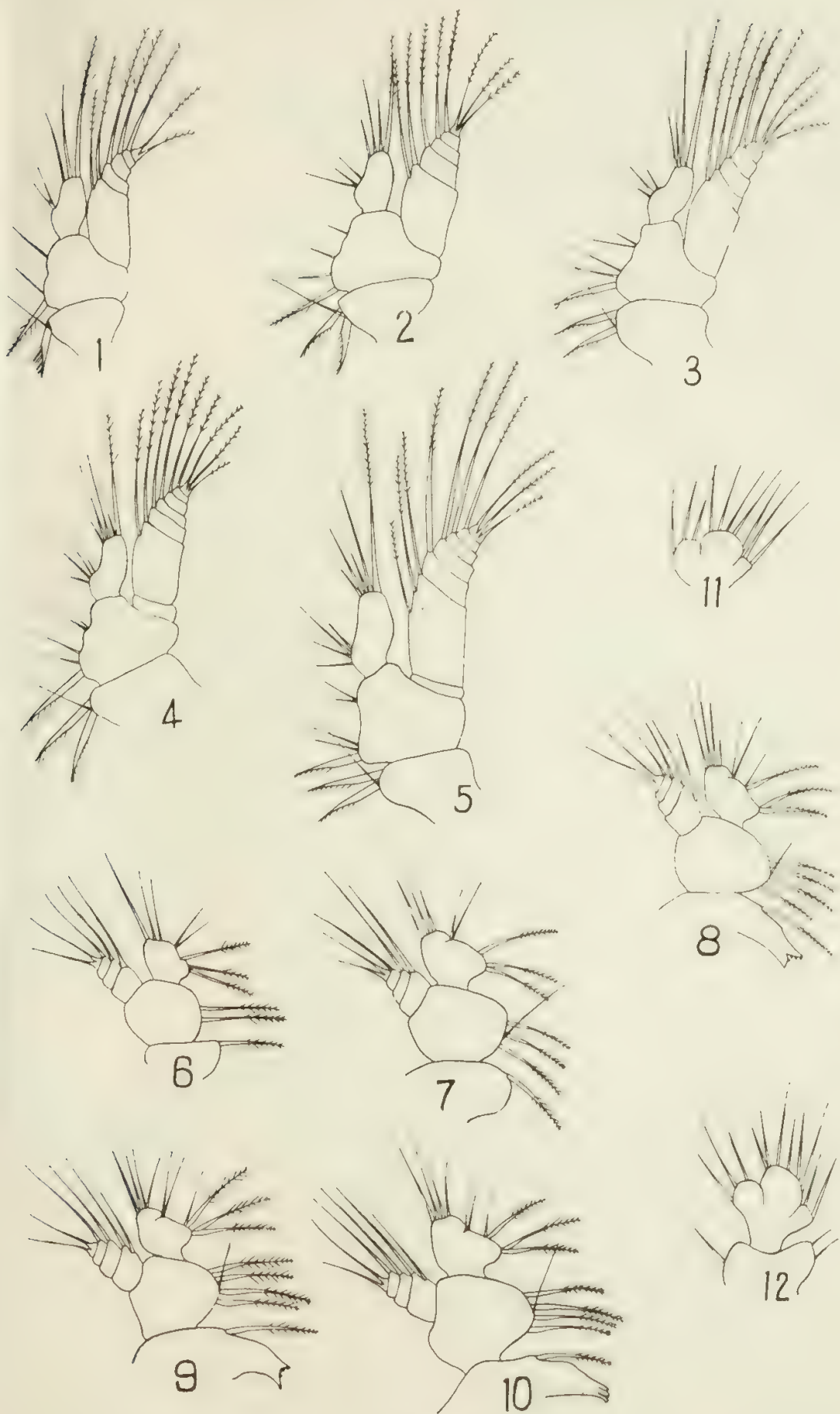


PLATE V.

PLATE VI.—*Brunella subattenuata* n. sp.

- Figs. 1 and 12. Abdomen of Copepodids I. and V. (female).  
Figs. 2 to 6. Mouth parts of Copepodid I.  
Fig. 7. First antenna of Copepodid II.  
Figs. 8 and 9. Maxilliped of Copepodids II. and III.  
Figs. 10 and 13. Fifth legs of Copepodids IV. and V. (female).  
Figs. 11 and 14. Fifth legs of Copepodids IV. and V. (male).



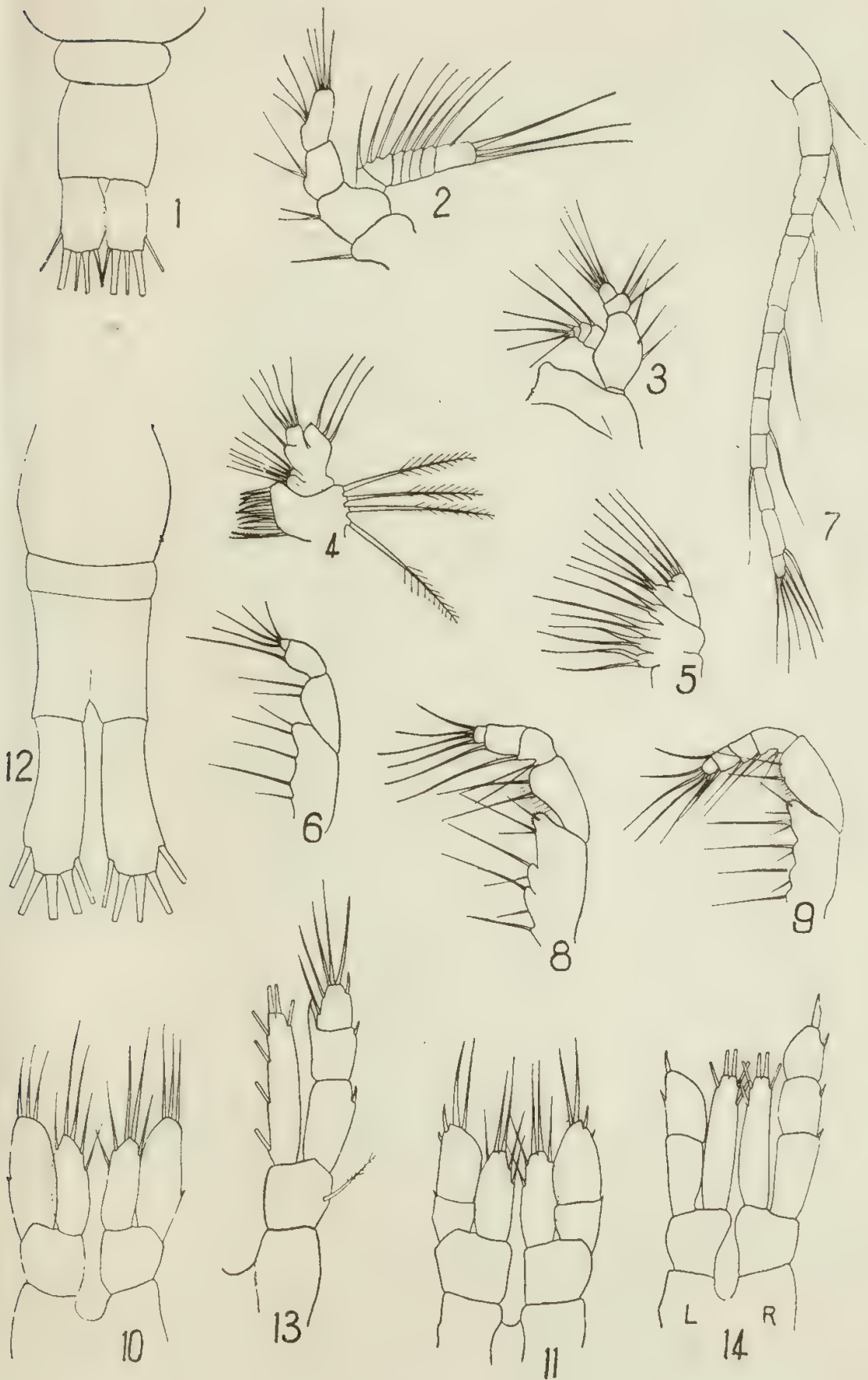


PLATE VI.



## 5.—MARINE COPEPODA FROM WESTERN AUSTRALIA.

### V.—A NEW SPECIES OF *PARAMESOCHRA*. WITH AN ACCOUNT OF A NEW HARPACTICOID FAMILY, THE REMANEIDAE, AND ITS AFFINITIES.

By A. G. NICHOLLS, Ph. D., University of Western Australia.

Read 8th December, 1942.

#### *Paramesochra longicaudata* sp. nov.

Occurrence.—Both sexes, in considerable abundance, were washed from sand 15 to 30 centimetres below the surface, between tide marks, at Cottesloe Beach (six miles from Perth).

Female.—Length 0.30–0.33 mm. Body of usual shape, with metasome wider than urosome. Rostrum very small and fused with the head. First antenna 7-segmented, with a large sensory filament on the fourth segment; second antenna 3-segmented, the middle segment with an outer seta, exopod 1-segmented, with three lateral and two terminal setae; mandible palp 4-segmented, the distal ramus 3-segmented, the terminal segment very small and bearing two end setae; maxillule with exopodal lobes; maxilla with three inner lobes and a segmented terminal portion; maxilliped 3-segmented, with three terminal claws. The terminal segment of the distal ramus of the mandible palp can be made out only with an immersion lens.

First legs with both rami 2-segmented and prehensile, endopod longer than exopod; second, third, and fourth legs with 3-segmented exopods and 2-segmented endopods, variously armed; fifth legs with inner expansions fused into a large plate which covers the genital area. In the specimen figured (fig. 1, female and fig. 2, p5 female) the basal expansion was asymmetrical, but other specimens showed no asymmetry (fig. 2, g.a.). Caudal rami a little more than three times as long as wide and twice as long as anal segment, armed with two unequal terminal setae, the longer being shorter than the urosome, and two short outer marginal setae, the distal being spine-like and pectinate. Egg-sac single, usually with three elongate eggs, similar to that shown for *Leptopsyllus constrictus* (Nicholls, 1935, p. 384).

Male.—Length 0.30 mm. Differs from the female in having a 5-segmented urosome, a modified first antenna in which only six segments could be seen, and in the fifth and sixth legs. In all other respects the male resembles the female.

This species is closest to *P. belandieri* Kunz (1930, 1935) from which it differs chiefly in the structure of the end segments of the fifth legs of both sexes.

Wilson (1932) placed the genus *Emertonia* in the Canthocamptidae, and comparison shows that it is closely related to the genera *Leptopsyllus*, *Paramesochra*, and *Remaneia* which have also been included in that family. A close study shows that this family has been derived from the same stock as the Diosaccidae and that the four genera referred to here cannot remain in the Canthocamptidae since they have no affinity with the Diosaccidae. It is proposed, therefore, to establish for them a new family, the Remaneidae.



(to be defined below) and it will be shown that the affinities of this group are clearly with the Tachidiidae. In order to establish this relationship it will be necessary briefly to review the latter as at present constituted.

In his work on the Crustacea of Norway (1911) Sars included nine genera in this family: *Tachidius* Lilljeborg, *Pseudotachidius* T. Scott, *Tachidiella* Sars, *Tachidiopsis* Sars, *Robertsonia* Brady, *Danielssenia* Boeck, *Psammis* Sars, *Fultonina* T. Scott, and *Argestes* Sars, but, as he pointed out (loc. cit., p. 437) the last two should more properly be included in the Cletodidae. In the Systematic List prefacing his work (pp. IX.-XIV.) this change was made. In 1921 he included also *Euterpina* Norman in this family.

Monard (1927) included in the Tachidiidae all those genera originally placed there by Sars; he retained *Jonesiella* (which Sars had regarded as synonymous with *Danielssenia*) for the single species *brucei*, and added *Thompsonula* T. Scott. At the same time he placed the Tachidiidae at the start of the Chirognath Series instead of at the end, where Sars had placed it owing to the resemblance of some of its members to the Cletodidae.

Gurney (1927) removed *Robertsonia* to the Diosaccidae and later (1932, p. 17) restated his reasons for so doing since Monard (1928) had disputed the validity of this transference. In this later work Gurney included *Fultonina* and *Argestes* in the Cletodidae and comments (p. 18) that without *Robertsonia* the family "seems a natural one, and one of the most primitive."

In the same year Wilson (1932) added two more genera, *Rathbunula* and *Echinocornus*, to the family and these are referred to by Monard (1935) in a discussion of the family. Willey (1935) added yet another genus, *Argestigens*.

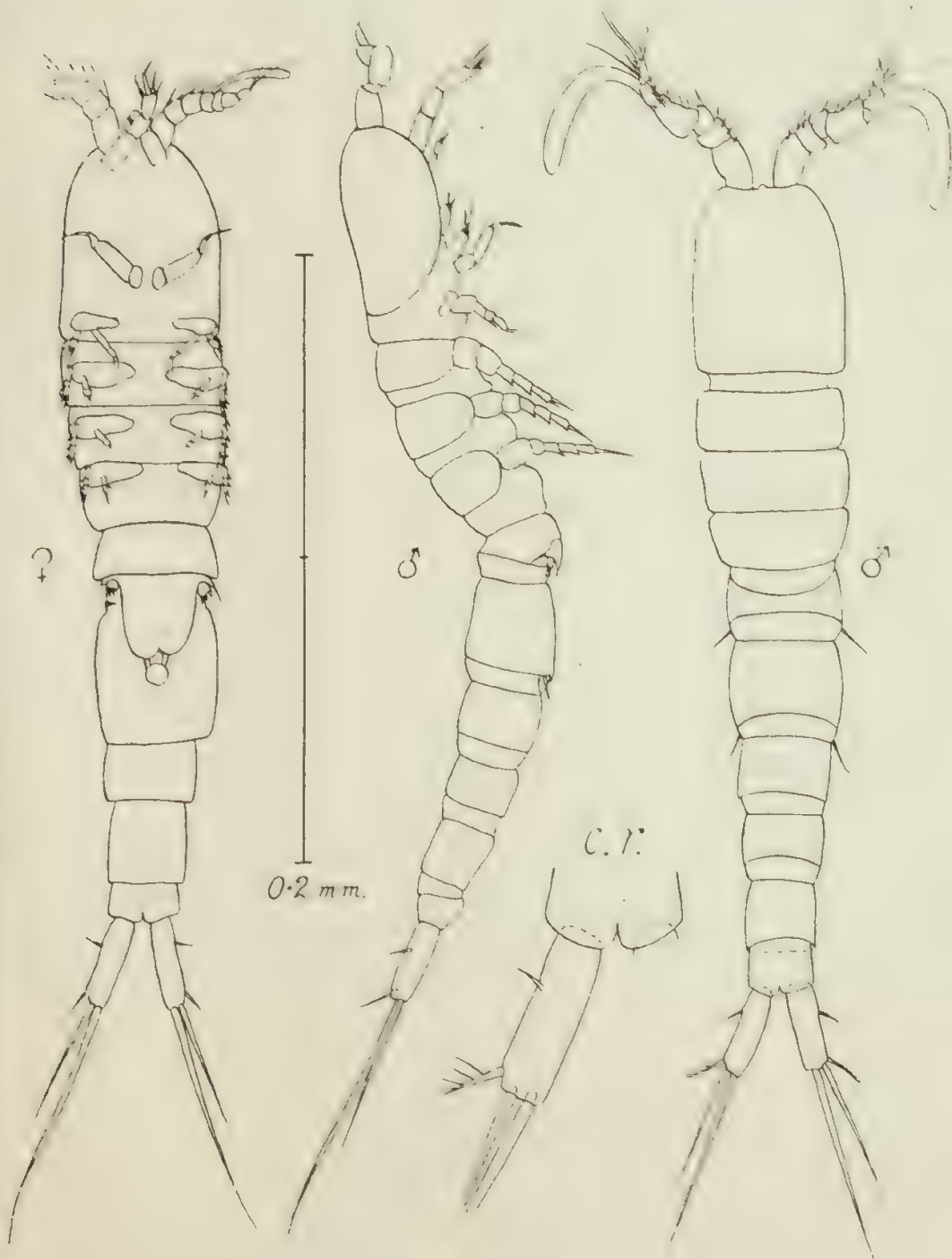
That *Robertsonia* is truly a Diosaccid has been amply demonstrated by Lang (1935) and, in his revision of the Thalestridae (1936a), he showed that *Pseudotachidius* is a Thalestrid. In his later revision of the Cletodidae (1936b) he showed that *Jonesiella brucei* belongs to *Pseudomesochra* and is thus a Diosaccid and, finally, he established the position of *Argestigens*, *Argestes*, and *Fultonina* in the Cletodidae.

Of *Rathbunula*, Monard (1935, p. 16) drew attention to its resemblance to *Thompsonula*. In Wilson's key (1932, p. 582) these genera are distinguished only by details of the fifth legs and, in fact, the second species of *Rathbunula* described by Wilson, *R. curticauda* (p. 300, Pl. 20) would, according to his key, be nearer to *Thompsonula* than to *Rathbunula*. There can be little doubt that these genera are identical and Wilson's genus, therefore, becomes a synonym of *Thompsonula*.

Here, also, we must consider *Donsiella* Stephensen (1936). This genus was placed, with some hesitation by the author, in the Laophontidae. The reasons for its removal are given in a revision of this family (Nicholls, 1941). The shape of the body, with the urosome strongly demarcated from the metasome; the broad rostrum, fused with the cephalosome; the richly setose first antenna; the 3-segmented rami of the second and third legs; the fusion between the basal segments of the fifth legs of opposite sides; the caudal rami and, in the male, the chirocerate\* first antenna and modified third endopod are all Tachidiid characters, though not exclusive to this

\* The terms chirocerate and subchirocerate are anglicized forms of those used and defined by Lang (1935).

family. The somewhat modified exopod in one or more of the legs of the female of *Donsiella*, and typical of many species of *Laophonte* is, however, not confined to that genus, or family, but is also found in the Tachidiidae (*Tachidius brevicornis*, in Sars, 1911, Pl. CCXIX). Against these features we have to set only the structure of the first legs. In shape these are very like those of the Laophontids, which probably caused Stephensen to include it in this family, but, unlike that of the true Laophontids, the endopod is armed with *two subequal terminal claws*. The strongly prehensile condition of these legs may be associated with the commensal habit of the species, described by Stephensen. This condition of armature of the first endopod



Text fig. 1.—*Paramesochra longicaudata* sp. nov. Female in ventral view, male in lateral and dorsal views ( $\times 340$ ); caudal ramus ( $\times 670$ ).

is found also in the genus *Remanea* which, as will be shown below, is probably derived from the Tachidiidae. The caudal rami also show a striking resemblance to those of *Remanea*.

The genus *Clytemnestra* is also sometimes included in the Tachidiidae, notably by Wilson (1932, p. 292), but this genus differs in so many respects that it seems preferable to retain it in the separate family established by A. Scott (1909).

Thus the Tachidiidae is comprised of the following genera.

<i>Tachidius</i> Lilljeborg 1853,	<i>Psammis</i> Sars, 1909,
<i>Danielssenia</i> Boeck 1872,	<i>Tachidiopsis</i> Sars, 1911.
<i>Euterpina</i> Norman 1903,	<i>Echinocornus</i> Wilson, 1932.
<i>Thompsonula</i> T. Scott 1905,	<i>Donsiella</i> Stephensen, 1936.
<i>Tachidiella</i> Sars 1909,	

These nine genera fall into two well defined groups, distinguished as follows:—

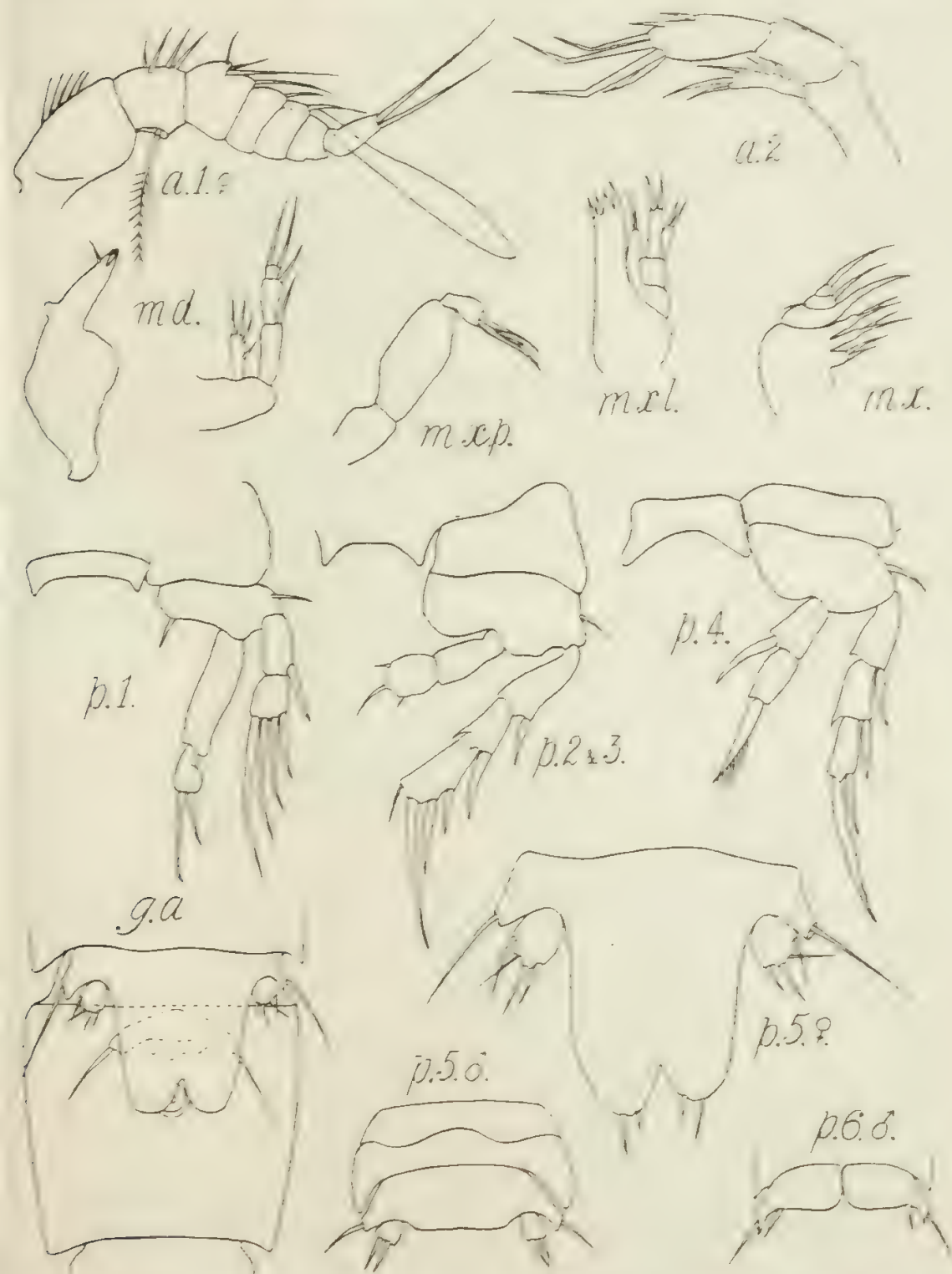
	<i>Tachidius</i> -Series.	<i>Danielssenia</i> -Series.
Body	Urosome demarcated from metasome	Urosome not demarcated from metasome
Rostrum	Fused with head	Free (except in <i>Danielssenia</i> )
First Antenna	5- to 9-segmented, with four segments in basal portion	4- to 6-segmented, with three segments in basal portion
Second Antenna	Basal segment divided (except in <i>Donsiella</i> )	Basal segment undivided
Genera	<i>Tachidius</i> , <i>Euterpina</i> , <i>Tachidiopsis</i> , <i>Tachidiella</i> , <i>Donsiella</i> .	<i>Danielssenia</i> , <i>Psammis</i> , <i>Thompsonula</i> , <i>Echinocornus</i> .

That the *Tachidius*-Series is the more primitive is shown by the condition of the maxilliped in the two genera *Tachidiopsis* and *Tachidiella*, in both of which it is clearly 3-segmented, with little or no development of claws. Common to both Series, but more apparent in the *Tachidius*-Series, is the great width of the coxa and basis of the swimming legs with a tendency for the exopod to be carried almost on the outer edge of the basis and for the endopod to occupy a more or less central position. This is noted by Sars (1911, p. 328) as "somewhat resembling in structure those of the Cyclopoida." This character is not very well developed in *Donsiella*, possibly owing to its peculiar habitat, and this genus probably occupies a position intermediate between the two Series referred to above, in some respects linking on to the Remaneidae.

The resemblance between *Remanea* and members of the *Tachidius*-Series is striking. In his description of *R. arenicola* Klie's (1929) figures are somewhat diagrammatic. I have, therefore, included here drawings made from specimens found in the Firth of Clyde in 1935, and recorded in 1939, in which the resemblances to the Tachidiids are clearly seen (Figs. 3 and 4). These are: the shape of the body, with its wide anterior and strongly demarcated urosome; rostrum bluntly rounded; first antenna 8-segmented with four in the basal portion and well supplied with plumose setae; second antenna with



the basal segment divided, bearing a 2-segmented exopod; mandible palp biramous, the distal ramus having retained its segmented condition which is lost in *Tachidiella* and *Tachidiopsis*, although these retain the lateral setae indicating the position of fusion, and the proximal ramus 1-segmented but with lateral setae showing its recent fusion from the 4-segmented condition found in *Tachidiopsis*; maxillule with well developed exopodal lobes; maxilla with three inner lobes and no claws, the proximal lobe partly divided and the terminal portion segmented; maxilliped clearly 3-segmented, weakly



Text fig. 2.—*Paramesochra longicaudata* sp. nov. All appendages are drawn to the same scale ( $\times 930$ ) except the genital area and male fifth and sixth legs ( $\times 650$ ).

prehensile, with several claw-like setae. The swimming legs are of the typical Tachidiid shape and richly spinous, but the first endopod has become prehensile. The caudal rami closely resemble those of the Tachidiids and the genital area is very similar to that of *Tachidius* (cf. Lang, 1935, fig. 4) and at the same time shows a resemblance to that of *Tigriopus* (Lang, 1934, p. 9, fig. 10), a further indication of its primitive position. In the male the first antenna is subchirocerate and in the Tachidiids it is chirocerate.

This resemblance is still to be seen in *Paramesochra* (cf. Sars, 1911, Supp. Pl. 45) and the peculiar fifth legs of this and allied genera can be related only to the condition found in several of the *Tachidiidae*. In this connection compare the various conditions found in the numerous species of *Paramesochra*, *Emertonia*, and *Leptosyllus* with those of *Tachidius littoralis* figured by Klie (1913, fig. 18), *Euterpina acutifrons* also figured by Klie (loc. cit., fig. 32), *Tachidius reductus* Monard (1935, Pl. I, fig. 11) and so on. In these is clearly seen the tendency to fusion and enlargement of the basal segment accompanied by reduction of the distal segments.

The Remaneidae then are Tachidiid derivatives which have taken to a sand-dwelling existence and have undergone the reduction usually found in Harpacticoids which have taken to this habitat.

#### REMANEIDAE fam. nov.

Body wide anteriorly, with a tendency towards intersegmental constriction, and tapering posteriorly or cylindrical and intersegmentally constricted throughout; genital segment undivided in female; rostrum never large, articulated in *Remanea*, small and fused in the other genera; first antenna 7- to 9-segmented; second antenna with basal segment always divided, exopod 1- or 2-segmented; mandible palp biramous, distal ramus with one, two, or three segments, proximal ramus 1-segmented or absent; maxillule with exopodal lobes; maxilla with one to four inner lobes; maxilliped 3-segmented, with at least two, subequal, terminal claws.

Legs with the basal portion very wide and rami variously segmented, but endopods with never more than two segments; fifth legs with basal segment more or less expanded, often to a considerable extent and fused in the mid-line to form a single large plate, distal segments usually small, sometimes reduced to setae.

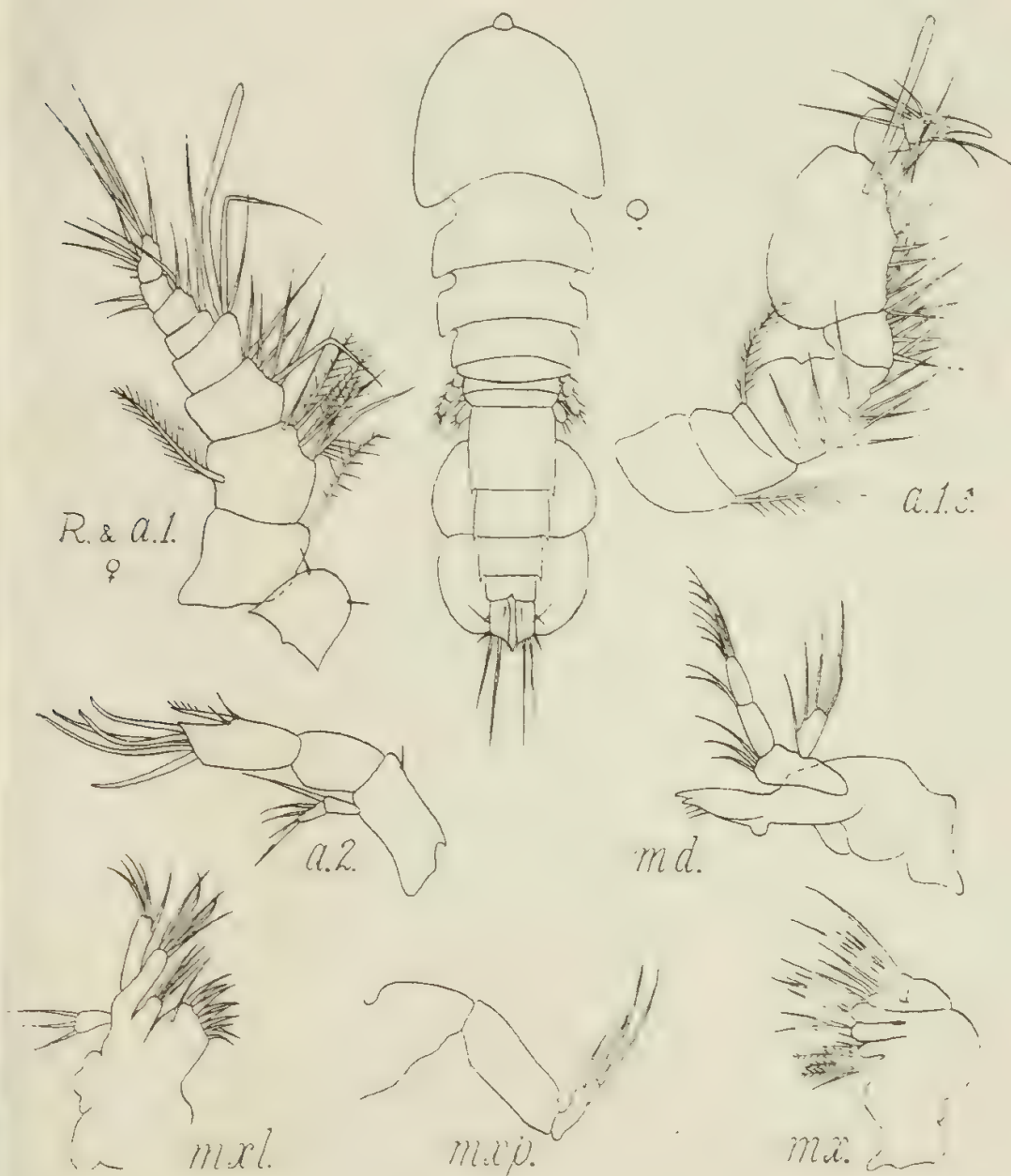
Male with first antenna subchirocerate, but often with three segments in the terminal, prehensile portion though it is doubtful if these segments are movable one upon another. None of the legs is modified.

These are exclusively sand-dwelling forms, never attaining a length greater than one millimetre.

#### KEY TO GENERA.

- |   |                                    |
|---|------------------------------------|
| 1. First exopod 3-segmented .. ..                             | <i>Remanea</i> Klie 1929.          |
| First exopod 2- or 1-segmented .. ..                          | 2                                  |
| 2. Body wide anteriorly, tapering .. ..                       | 3                                  |
| Body cylindrical, strongly constricted intersegmentally .. .. | <i>Leptosyllus</i> T. Scott 1894.  |
| 3. Mandible palp with 3-segmented distal ramus .. ..          | <i>Paramesochra</i> T. Scott 1892. |
| Mandible palp with 2- or 1-segmented distal ramus .. ..       | <i>Emertonia</i> Wilson 1932.      |

The members of this family are not very clearly defined from one another. There is little doubt that *Remanea* is the least reduced form and that *Paramesochra*, *Emertonia*, and *Leptopsyllus* are direct derivatives of *Remanea* in that order. It is in *Remanea*, therefore, that the affinities of the family will be most clearly shown and its relation to the Tachidiidae has already been demonstrated.



Text fig. 3.—*Remanea arenicola* Klie. Female ( $\times 170$ ); appendages are all drawn to the same scale ( $\times 540$ ).

There have been several attempts to clear up the confusion existing between *Paramesochra* and *Leptopsyllus*. Klie (1929, pp. 353, 358) united them under the older name *Leptopsyllus*, but suggested that a separation might be established on the presence or absence of an endopod on the second leg, together with certain differences in the caudal rami and fifth legs. Monard (1935, p. 61) separated them by defining *Leptopsyllus* as having a strongly elongated body and the endopods of the swimming legs lacking or reduced to one or two segments.



Kunz (1938, p. 228) in reviewing these attempts adopted the first character suggested by Klie and separated the two genera on the presence or absence of an endopod on the second leg. He discarded Monard's suggestion because both characters do not always occur together. But the same criticism applies to Klie's arrangement and Kunz himself selected only one of the characters suggested by Klie to distinguish the two genera.

The structure of the various forms included under these two names varies to an extraordinary extent and, as more species are described, it becomes increasingly difficult to find more than one feature which will be binding. In my opinion there is, in this case, less justification for selecting the presence or absence of an endopod on any particular leg to separate genera, particularly such genera as these in which this is the most variable feature, than there is in selecting body shape. In all these species the segmentation of the legs is very variable and the group as a whole is obviously undergoing rapid evolutionary changes. Amongst these varying features one character stands out as constant, namely the shape of the body, selected as the chief character by Monard. In *Paramesochra* and *Emertonia* it is always short compared with its width (only 4 to 7 times as long as wide), it is wide in front and tapers very distinctly posteriorly, whereas in *Leptopsyllus* the body is elongate (about 10 times as long as wide), cylindrical, and worm-like.

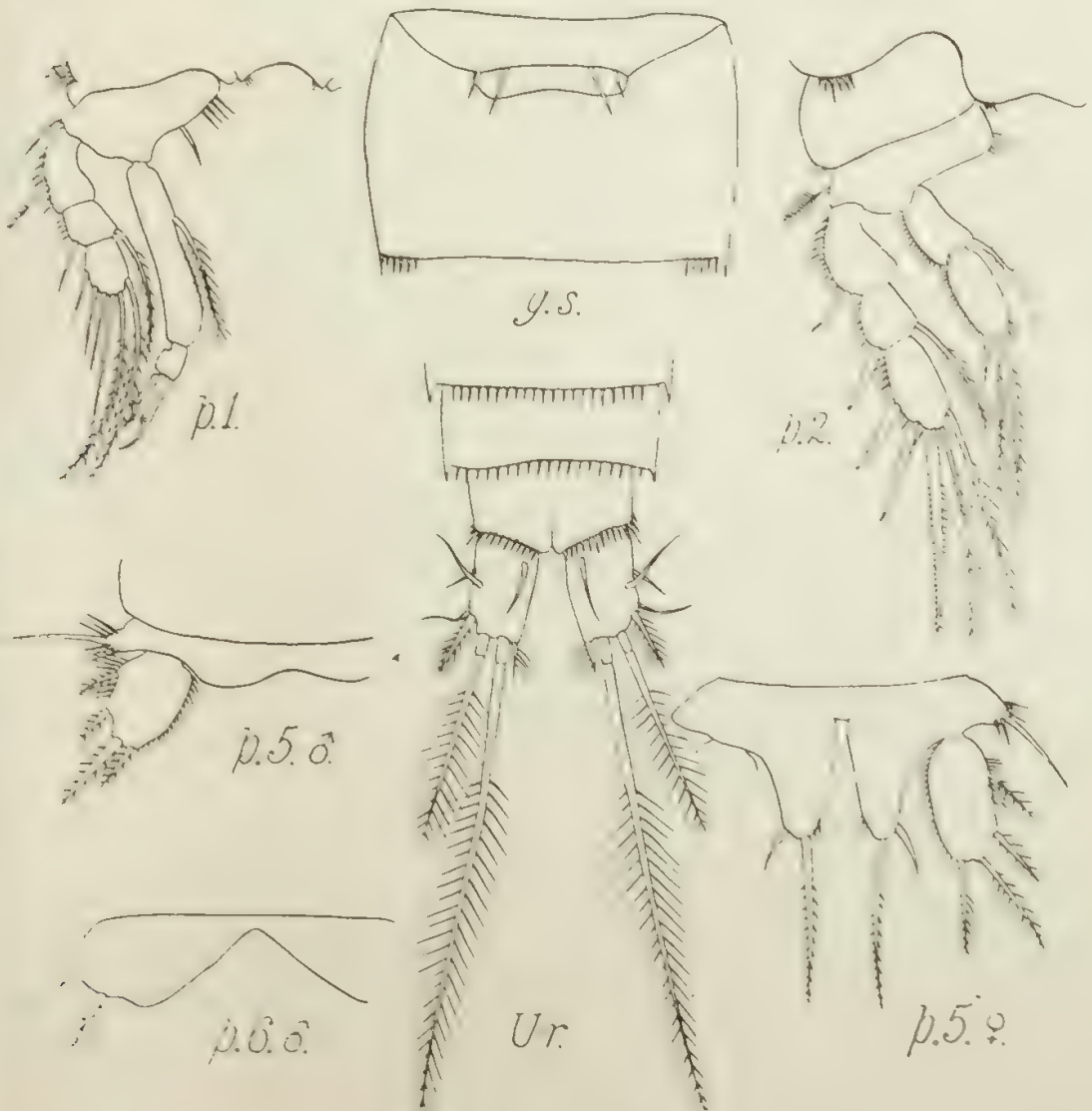
While we can accept a varying segmentation of the legs within a genus we cannot accept two such strikingly different types of body shape. How, for instance, can one reconcile as congeneric, species with such totally different forms of body as those of *P. minuta* (Nicholls, 1939, p. 337) on the one hand and those of *P. pterocaudata*, *P. similis*, and *P. helgolandica* (Kunz, 1938, pp. 233-236) on the other, and yet, according to Kunz's definition *P. minuta* cannot belong to *Leptopsyllus* and must belong to *Paramesochra*.

For this reason I propose, firstly, to separate under the name *Leptopsyllus*, all those forms which have the elongate, worm-like form of body. This removes six species, including *typicus* which was the first to be described and, in passing, it may be noted that *all* those forms in which there is no endopod on the second leg are thus included in this genus as well as one species, *minuta*, in which it is represented by a single segment.

Klie (1929, p. 353) states that in his opinion the diagnosis of *Leptopsyllus* given by T. & A. Scott (1895b) is better than that originally given by T. Scott (1894) and includes the genus *Paramesochra* described by T. Scott (1892) and, on these grounds, regards *Leptopsyllus* as invalid. The point about the difference in body shape which I have stressed here is very clearly seen in a comparison of the figures given by T. Scott when first describing these two genera. Compare the dorsal views of the females of *P. dubia* (1892, Pl. XII, fig. 18) and *L. typicus* (1894, Pl. IX, fig. 2). These differences were also noted by T. Scott in his descriptions. The diagnosis of *Paramesochra* (1892, p. 251) begins: "Body subpyriform; . . .," while that of *Leptopsyllus* (1894, p. 253) reads: "Body elongate, cylindrical, somewhat similar in form to *Cylindropsyllus* Brady." Thus T. Scott's original diagnoses stand in this respect at least.

Associated with this difference in body shape is a not unexpected difference in the shape of the egg-sac. In the wider forms the egg-sac contains two or three large, elongate eggs, two arranged side by side with the third, when present, placed transversely behind the first two and so imparting a

round shape to the sac as a whole, like that shown here for *Remanea arenicola* (fig. 3) which, however, has four eggs. This type of egg-sac is shown by T. & A. Scott (1895, Pl. V, fig. 1) for *intermedius*, by Nicholls (1935) for *constrictus* (p. 384) and for *minor* (p. 388), and where reference to the egg-sac has been made elsewhere in the literature in no case is there any indication that it is other than round. The egg-sac of *holsatica* Klie (1929, p. 356) is described as round and with few eggs; for *similis* Kunz (1938, p. 235) states that it contains two eggs, and that of *intermedius* is described as having a few large eggs (T. & A. Scott, 1895, p. 51); while that of *longicaudata* sp. nov., shows a condition similar to that of *constrictus*. In the case of *P. major* Nicholls (1939, p. 336), which is a large species, there are nine or ten eggs.



Text fig. 4.—*Remanea arenicola* Klie. Urosome ( $\times 400$ ); other parts are all drawn to the same scale ( $\times 525$ ).

On the other hand in *L. littoralis* Nicholls (1939, p. 328), the only species of those here regarded as belonging to *Leptopsyllus*, in which the egg-sac has been described, it is elongate "with five or six spherical eggs carried one behind the other." This is the usual type of egg-sac found in those forms of Harpacticoids having elongate bodies, and is shown particularly by the psammophilous genera: *Leptastacus*, *Paraleptastacus*, *Evansula*, *Stenocaris*, etc.



The remaining species show a considerable variation in the segmentation of the endopods of legs two to four and, at first sight, might well all be included under the name *Paramesochra*. However, this group can further be divided on the structure of the mandible palp. In certain species the distal ramus of the palp is clearly 3-segmented, whereas in the remainder it has only one or two segments. Those with three segments comprise the genus *Paramesochra* while the latter group falls into Wilson's genus *Emertonia*. This is in complete conformity with the suggestion put forward by the late Dr. Wilson in a personal communication (August, 1937) in which he wrote: "Let me suggest that there are really three valid genera as follows, *Leptosyllus* with the single species *typicus*, *Paramesochra* with the species *dubia*, *intermedia*, *herdmani*, *robertsoni*, (and) *Emertonia* with the species *gracilis*, *minor*, *constrictus*, *holsatica*, *acutata*." Since he wrote, many new species have been described.

We can only assume that owing to the active evolution proceeding within this group of sand-dwellers, in which the need for an endopod grows less important in correlation with the habitat and method of progression, this ramus is undergoing reduction to be finally lost through disuse, a condition already reached in several species (both *littoralis* and *spinipes* Nicholls (1939) lack endopods on the second, third, and fourth legs).

*Paramesochra* is most closely related to *Remanea* in body shape but shows a certain reduction in mouth parts and legs. The whole group has taken on a sand-dwelling existence and the body form is related to this habitat. It is reasonable to assume that these forms first entered this habitat through coarse sand. *Remanea*, which is relatively wide, has been found only in coarse sand; *Paramesochra*, which includes relatively large species, is unable to inhabit fine sand; *Emertonia* has been able to penetrate fine sand by a reduction in size of the body (none over 0.5 mm.) without great modification in shape; *Leptosyllus* has acquired the same ability without loss of size by modification in shape of the body, which has become slender and worm-like, and may thus be regarded as the most successful form.

The two genera most difficult to distinguish on body shape are *Paramesochra* and *Emertonia*, but these are easily separated by the structure of the mandible palp, already referred to. In *P. dubia*, the type species, T. Scott (1892, Pl. XII, fig. 24) shows the distal ramus of the mandible palp with three distinct segments; Sars is noncommittal in his description of the species but his figure (1911, Supp. Pl. 45, M) of the appendage could well be construed as showing a 3-segmented distal ramus. In *intermedia* T. & A. Scott (1895, Pl. V, fig. 4) it is shown as 2-segmented whereas Kunz (1938, p. 231, and Abd. 1, fig. 5) in redescribing this species shows that this ramus is clearly 3-segmented. The two species *pterocaudata* and *helgolandica* Kunz (1936 and 1938) both show a similar condition. For *herdmani* and *similis* the mouth parts have not been described but other features leave little doubt that they should be included in this genus.

In *Emertonia*, also, the mandible palp is biramous. The mouth parts were not described by Wilson (1932) but in the letter referred to above he stated that this is one of the characters by which he distinguished *Emertonia* from *Leptosyllus*, with which I had regarded it as synonymous (1935). The other characters which he enumerated in this letter as distinguishing the two genera are no longer of value owing to the addition of several new species



to both genera. In only two of the species here included in *Emertonia* (*minor* and *constricta*) is the segmentation of the mandible palp known and in both cases the distal ramus is 2-segmented.\*

In *Leptopsyllus* a biramous mandible palp is usually found and the distal ramus is always 2-segmented, the proximal ramus 1-segmented or absent. The type species, *typicus* T. Scott (1894, Pl. IX, fig. 5) is the only one in which there is no proximal ramus.

Thus the mandible palp serves as a distinguishing character between the first two genera, and the body shape between the last two. This re-arrangement of the species modifies Kunz's suggestion that the presence or absence of an endopod on the second leg should decide the genus. This suggestion, which was adopted by me with reservation in 1939, is unnatural and fails to take into account Wilson's genus *Emertonia*, as well as the noticeable difference in body shape found in the species under consideration. The arrangement suggested here, if so happens, does group the species according to the segmentation of the legs since those with 2-segmented endopods mostly fall into *Paramesochra*, those with only 1-segmented endopods are mostly contained in *Emertonia*, and those species in which the endopod is lacking on at least one of the legs are all to be found in *Leptopsyllus*.

There is thus little doubt on the grounds of body shape and segmentation of the endopods that *Emertonia* is intermediate between *Paramesochra* and *Leptopsyllus*.

#### REMANEA Klie 1929.

Klie, 1929, p. 363.

Body wide in front, tapering posteriorly, head distinctly wider than metasome which is intersegmentally constricted; rostrum rounded, articulated; first antenna 8-segmented; second antenna with basal segment divided, exopod 2-segmented; mandible palp biramous, distal ramus 2-segmented, proximal 1-segmented; maxillule with exopodal lobes; maxilla with four inner lobes; maxilliped 3-segmented, with two long and two shorter terminal claw-like setae. Legs with 3-segmented exopods and 2-segmented endopods; first endopod longer than exopod and basal segment much longer than distal; fifth legs with large basal expansion, those of opposite sides fused basally, distal segment well developed. Caudal rami bearing plumose setae at outer distal corners. One egg-sac. Male first antenna subchirocerate; fifth legs with little or no basal expansion.

One species, the genotype, *R. arenicola* Klie (1929, pp. 364-367, figs. 44-56).

#### PARAMESOCHRA T. Scott 1892.

T. Scott, 1892, p. 251.

Body wide anteriorly, tapering posteriorly, urosome distinctly narrower than metasome; rostrum small, fused with head; first antenna 7- to 9-segmented; second antenna with basal segment divided, the middle segment bearing an outer seta, exopod 1-segmented; mandible palp biramous, distal ramus 3-segmented, proximal 1-segmented; maxillule with exopodal lobes;

\* In *constricta* this ramus was described and figured as composed of a single segment but re-examination of fresh material shows that it is truly 2-segmented. I am also able to confirm Kunz's (1938, p. 238) correction to my description of the fifth legs, in which the fused basal segments are expanded in the usual way. The tips each bear two long, unequal setae, the longer inner one being plumose.

maxilla with three inner lobes; maxilliped 3-segmented, with claw-like setae. First leg with endopod usually longer than exopod, basal segment elongate, unarmed, and much longer than distal segment; both rami 2-segmented; second and third legs usually with 2-segmented endopods (segments fused but clearly recognisable in *herdmani*) and 3-segmented exopods; fourth leg with 2-segmented endopod (1-segmented in *intermedia* and *major*) and 3-segmented exopod (2-segmented in *intermedia*), endopod usually with inner seta on basal segment and stout, terminal, spine-like seta, usually tufted, on distal segment; fifth legs with large basal expansions more or less entirely fused, usually with two setae.

There are nine species, five certain:

<i>dubia</i> T. Scott 1892,	<i>helgolandica</i> Kunz 1936,
<i>pterocephala</i> Kunz 1936,	<i>longicaudata</i> sp. nov.
<i>similis</i> Kunz 1936,	

and four probable:

<i>intermedia</i> (T. & A. Scott) 1895,	<i>herdmani</i> (Thompson & Scott) 1900,
<i>robertsoni</i> (T. & A. Scott) 1895a,	<i>major</i> Nicholls 1939.

As the genotype, *P. dubia* T. Scott, and redescribed by Sars (1911) may be named.

#### KEY TO THE SPECIES.

- |  |  |
|--|--|
| 1. Fourth exopod 3-segmented .. .. .                                 | 2.                                       |
| Fourth exopod 2-segmented .. .. .                                    | <i>intermedia</i> (T. & A. Scott) 1895.  |
| 2. Second and third endopods 2-segmented .. .. .                     | 3  |
| Second and third endopods 1-segmented .. .. .                        | 7  |
| 3. Basal segment of first antenna strongly hooked distally .. .. .   | <i>dubia</i> T. Scott, 1892              |
| Basal segment of first antenna not hooked .. .. .                    | 4  |
| 4. Anal segment with lateral, backwardly projecting points .. .. .   | <i>pterocephala</i> Kunz, 1936.          |
| Anal segment without such points .. .. .                             | 5.                                       |
| 5. Basal segment of third endopod with an inner seta .. .. .         | <i>similis</i> Kunz, 1936.               |
| Basal segment of third endopod without setae .. .. .                 | 6  |
| 6. End segment of fifth leg tapering to end in a large spine .. .. . | <i>helgolandica</i> Kunz, 1936.          |
| End segment of fifth leg rounded, bearing setae only .. .. .         | <i>longicaudata</i> sp. nov.             |
| 7. Fourth endopod 2-segmented .. .. .                                | 8  |
| Fourth endopod 1-segmented .. .. .                                   | <i>major</i> Nicholls, 1939.             |
| 8. Second endopod without seta .. .. .                               | <i>robertsoni</i> (T. & A. Scott) 1895a. |
| Second endopod with seta .. .. .                                     | <i>herdmani</i> (Thompson & Scott) 1900. |

## EMERTONIA Wilson, 1932.

Wilson, 1932, p. 256.

Body slender anteriorly, gradually tapering posteriorly; rostrum small, fused with head; first antenna 7-segmented; second antenna with basal segment divided, middle segment unimodal, exopod 1-segmented; mandible palp bifurcous, distal ramus 2-segmented, proximal ramus 1-segmented; maxillule with exopodal lobes; maxilla with two or three inner lobes; maxilliped 3-segmented, armed with claws. First legs with each ramus 1- or 2-segmented; second to fourth legs with 1-segmented endopods (2-segmented in *minor*) and in fourth legs at *minor*, and 3-segmented exopods; fifth legs with basal segment scarcely expanded, or large as in *Paramesochra*.

There are seven species:

<i>minor</i> (T. & A. Scott) 1895a.	<i>coelebs</i> (Monard) 1935.
<i>holsatica</i> (Klie) 1929.	<i>constricta</i> (Nicholls) 1935.
<i>gracilis</i> Wilson, 1932.	<i>pygmaea</i> (Nicholls) 1939.
<i>acutata</i> (Klie) 1934.	

Of these *E. pygmaea* may be regarded as the genotype.

## KEY TO THE SPECIES.

1. Fourth endopod 2-segmented .. .. .	2
Fourth endopod 1-segmented .. .. .	3
2. Basal expansion of fifth legs rounded.	
completely fused .. .. .	<i>minor</i> (T. & A. Scott) 1895a.
Basal expansion of fifth legs produced into points, only partially fused ..	<i>acutata</i> (Klie) 1934.
3. First exopod 2-segmented .. .. .	4
First exopod 1-segmented .. .. .	<i>gracilis</i> Wilson, 1932.
4. First endopod 2-segmented .. .. .	5
First endopod 1-segmented .. .. .	<i>constricta</i> (Nicholls) 1935.
5. Caudal rami without inner setae .. .. .	6
Caudal rami with inner setae .. .. .	<i>coelebs</i> (Monard) 1935.
6. Caudal rami with stout spine at outer distal corner .. .. .	<i>holsatica</i> (Klie) 1929.
Caudal rami with plumose seta in place of spine .. .. .	<i>pygmaea</i> (Nicholls) 1939.

## LEPTOPSYLLUS T. Scott, 1894.

T. Scott, 1894, p. 253.

Body cylindrical, scarcely tapering, intersegmentally constricted; head little or no wider than metasome; rostrum small, fused with head; first antenna 7- to 9-segmented; second antenna with basal segment divided, middle segment with seta, exopod 1-segmented; mandible palp bifurcous or trifurcous, distal ramus 2-segmented, proximal 1-segmented; maxillule with exopodal lobes; maxilla with two or three inner lobes; maxilliped 3-segmented, with elongate setae. First legs with 2-segmented endopods, exopod 1- or 2-segmented, second and third legs with 3-segmented exopods and usually



without endopods (present and 1-segmented in both legs of *minuta*, and in third legs of *arcticus*); fourth legs with 3-segmented exopods, and variously segmented endopods; fifth legs with basal segment enlarged, fused or separate.

There are six species:

<i>typicus</i> T. Scott, 1894,	<i>spinipes</i> Nicholls, 1939,
<i>arcticus</i> (Lang) 1936,	<i>paratypicus</i> Nicholls, 1939,
<i>littoralis</i> Nicholls, 1939,	<i>minutus</i> (Nicholls) 1939.

It is difficult to select a type species for this genus. In both *arcticus* and *minutus* endopods are present on the second and third legs, *littoralis* has atypical fifth legs, *spinipes* departs in the fifth legs and caudal rami. *paratypicus* is known only from the male and *typicus* only from the female and, moreover, has the fourth endopods with two segments. Under the circumstances it is probably advisable to select *typicus* although not truly typical. This was the first species to be described and conforms to the diagnosis given above.

#### KEY TO THE SPECIES.

1. Second endopod absent .. .. .	2
Second endopod 1-segmented .. .. .	<i>minutus</i> (Nicholls) 1939.
2. Third endopod absent .. .. .	3
Third endopod 1-segmented .. .. .	<i>arcticus</i> (Lang) 1936.
3. Fourth endopod absent .. .. .	4
Fourth endopod present .. .. .	5
4. First exopod 1-segmented .. .. .	<i>littoralis</i> Nicholls, 1939.
First exopod 2-segmented .. .. .	<i>spinipes</i> Nicholls, 1939.
5. Fourth endopod 1-segmented .. .. .	<i>paratypicus</i> Nicholls, 1939.
Fourth endopod 2-segmented .. .. .	<i>typicus</i> T. Scott, 1894.

There remains unplaced the species described by me (1939, as *P. laurentica*) from a single female, in which all the exopods were 2-segmented. The description is inadequate for placing the species satisfactorily since we lack knowledge as to its body shape and other details. It is probable that it constitutes another genus, since the exopods of the legs are all 2-segmented, and the second antenna is probably without an exopod.

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## 6.—FIVE NEW MICROCOTYLIDS FROM FISH FROM WESTERN AUSTRALIAN WATERS.

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Read 8th December, 1942.

## INTRODUCTION.

At the suggestion of Professor G. E. Nicholls, an investigation of local fish for new parasitic types was commenced. Fish from various localities were obtained at frequent intervals over a period of seven months, from March to September, during 1942. From the gills of five of the species of fish examined, monogenetic parasites were obtained. These all appeared, from a study of the Zoological Record, to be new species of the Genus *Microcotyle*. The outstanding features in which the parasites diverge from what seem to be the nearest related species are tabulated at the end of each described species. The study of the Zoological Record with reference to the host upon which the various species of *Microcotyle* were obtained, appears to corroborate the statement made by Brown (1929) regarding Microcotylids that "There appears to be a certain specific relationship between the parasites and their host." It is interesting to note that related parasites are usually discovered on related fish, e.g., *M. mugilis* (Vogt, 1879, according to Yamaguti, 1938), was obtained from *Mugil cephalus*, and *M. agonostomi* from *Agonostomus forsteri*. Both *M. mugilis* and *M. agonostomi* show a close relationship and their respective hosts are genera within the same family: Mugilidae. The case of *M. parasillaginae* is of interest because it has been obtained from the same host as *M. sillaginae*, viz., *Sillaginodes punctatus*. Although the two parasites are very closely related, they are certainly different species, but whereas *M. sillaginae* occurs only on fish from Victorian waters, *M. parasillaginae* is from fish from Western Australian waters.

The parasites obtained and the hosts on which they were located were:—

PARASITE.	HOST.
<i>Microcotyle agonostomi</i>	<i>Agonostomus forsteri</i> .
<i>M. — arripis</i>	<i>Arripis georgianus</i> .
<i>M. — temnodontis</i>	<i>Temnodon saltator</i> .
<i>M. — parasillaginae</i>	<i>Sillaginodes punctatus</i> .
<i>M. — odacis</i>	<i>Odax semifasciatus</i> .

All measurements were made from specimens mounted in balsam. The fixative which was most successful was Kleinenberg's Pierie Acid. Borax carmine was found to be a reliable stain which could be used to give consistently good results. However, Cochineal Alum Carmine and Acetic Acid Alum Carmine proved to give excellent results, if carefully handled. Of the latter two, Acetic Acid Alum Carmine appeared to be the better.

In conclusion, the writer must express her thanks to the Government Fisheries Department, whose assistance in obtaining material has proved

invaluable, and, without which help, this work would have been made much more difficult. Also the writer is indebted to Professor G. E. Nicholls, whose encouragement and untiring interest in this work has been very much appreciated; and finally to Miss O. Goss, B.Sc. (Hons.), who has so readily given her assistance.

## DESCRIPTION OF SPECIES.

### CLASS TREMATODA.

#### SUBCLASS MONOGENA.

#### Order POLYOPISTHOCOTYLEA.

Family **MICROCOTYLIDAE** Faschenberg (1879).

Genus **MICROCOTYLE** Van Beneden and Hesse.

**Microcotyle agonostomi** sp. nov. (Pl. I, Fig. 1.).

*Habitat*: Gills.

*Host*: *Agonostomus forsteri*. Yellow-eyed Mullet or Pilchard.

*Locality*: Swan River, Mandurah, Bunbury, Denmark, Albany.

#### *Occurrence.*

From the end of March until the middle of September, 85 *Agonostomus forsteri* were examined for gill parasites and a total of 91 of these Microcotylids were obtained. Omitting the fish from which none of these parasites were recovered, the average number of parasites obtained from each fish was two. This form, *M. agonostomi*, was usually found amongst the central gill filaments of each gill bar.

Of the fish from Mandurah, it was found that the number of parasites obtained increased in number in May, June, July and August, being most abundant during the period from the latter half of July to the end of the first half of August. They then rapidly decreased in number.

#### *General Structure.*

The external appearance of *Microcotyle agonostomi* presents a squat, compact form, and is quite large in comparison with other forms of *Microcotyle*. Total length of the body averages 3.84 mm., of which 0.64 mm. is the cotylophore, which hence constitutes 1/6th of the total body length. Cotylophore is not sharply differentiated from the rest of the body. Body reaches its maximum width of 1.04 mm. at approximately the middle of the body length. Body tapers gradually to a small extent anteriorly and posteriorly. Across the genital armature the width is 0.64 mm., and at the level of the oral suckers it measures 0.32 mm. Width of the most anterior part of body is 0.288 mm. Situated 0.48 mm. from the anterior end is a conspicuous lobe on each lateral margin of the body and each averages 0.032 mm. wide and 0.112 mm. long. These lobes seem to constitute a characteristic feature for this particular species of *Microcotyle*. Width of the anterior margin of the cotylophore is 0.72 mm. and its posterior border is 0.16 mm. wide. Cotylophore carries 34 pairs of suckers each of which has the characteristic chitinous framework (Pl. I, Fig. 2). Average width of each sucker is 0.096 mm. and each is 0.048 mm. long. Oral suckers have no transverse septa, and their margins bear a series of minute simple hooks. As well as these anterior oral suckers, and the posterior suckers situated on the cotylophore, the body of the para-



site bears a pair of dorsal, sub-circular suckers, 0.72 mm. from the anterior end. Each sucker is 0.288 mm. from the lateral margin, and each has a width of 0.048 mm. and a length of 0.064 mm. Pharynx lies immediately behind the oral suckers and is followed on the ventral surface by the genital atrium with its armature consisting of three part circles of 11, 12, 11 hooks respectively. It lies 0.256 mm. from the anterior extremity of the body. Each spine is a curved structure 0.016 mm. long. This armature measures 0.064 mm. in length and 0.112 mm. in width (Pl. I., Fig 3).

#### *Alimentary Canal.*

The buccal cavity is situated at the extreme anterior end of the body and contains the pair of oral suckers. Closely following the region where these suckers are situated is the pharynx which is 0.064 mm. wide and 0.096 mm. long, and this leads into the oesophagus which has a length of 0.24 mm. This oesophagus has several lateral branches. The intestinal bifurcation immediately posterior to the genital atrium and the two longitudinal ducts run along the lateral margins of the body where they form lateral ramifications. The major longitudinal canals converge in the posterior portion of the body, and the ramifications extend 0.56 mm. into the cotylophore, even beyond the posterior extent of the vitelline follicles.

#### *Excretory System.*

Along either side of the body and ventral to the alimentary canal is a longitudinal excretory duct.

#### *Nervous System.*

The brain is rectangular and situated 0.144 mm. from the anterior end of the body. It is situated dorsally to the oesophagus. A pair of anterior nerves are present and a pair of posterior nerves pass along either side of the body.

#### *Reproductive Systems.*

*Male.*—There are 29 testes lying in a field surrounded by vitelline follicles, except at the anterior border. The field occupies a little less than half of the total body length. The testes fit closely into one another, thus forming a compact mass. Size of an average testis is 0.112 mm. long and 0.192 mm. wide. The vas deferens is a thick-walled tube, very much convoluted, and running on the dorsal side of the body. This terminates in the male aperture in the genital atrium.

*Female.*—The ovary is situated towards the posterior end of the anterior half of the body. It is a somewhat compressed form anteriorly to posteriorly. Viewed dorsally the ovary commences as a mass medianly and curves to the left side where it enlarges. It then passes to the right side by a constricted bridge, enlarges again, and passes posteriorly towards the left side again, where it is joined by the common vitelline duct. Maximum length of the ovary is 0.32 mm. Vitellarium begins at 0.288 mm. from the anterior end of the body. The lateral fields of the vitellarium meet anteriorly in the middle line. Vitellarium extends along either lateral field of the body and unites posteriorly in the cotylophore behind the testes. Vitellarium passes for 0.48 mm. into the cotylophore. Arising 0.72 mm. from the anterior end of the body, the paired ventral vitelline ducts pass posteriorly for 0.48 mm. Each duct is comparatively wide, having a maximum width of 0.096 mm.



The two ducts unite and pass posteriorly as the common vitelline duct for 0.32 mm. This joins the oviduct, and the genito-intestinal canal passes to the left. The uterus curves to the right, with the ootype and shell gland at its base, then passes anteriorly to the genital atrium as a thin-walled straight duct. Two or three eggs may be seen in the uterine duct at the same time.

### *Egg.*

Eggs were seen both in the uterus and also after they had been laid. Each is oval in shape and at the end opposite to the operculum an appendage 0.112 mm. long is present. The extremity of this appendage bears a small hooklike arrangement (Pl. 1, Fig. 4)

Length of egg, including the tail, is 0.336 mm., so that, excluding the tail, it is 0.224 mm. Maximum width of the egg is 0.144 mm.

### *Summary of Specific Characters.*

Average length of body—3.84 mm.

Average length of cotylophore—0.64 mm.

Average length of rest of body anterior to cotylophore—3.20 mm.

Average width of oral suckers—0.096 mm.

Average length of oral suckers—0.048 mm.

Average length of suckers of cotylophore—0.048 mm.

Average width of suckers of cotylophore—0.096 mm.

Average distance of pair of dorsal suckers from anterior end—0.72 mm.

Average width of dorsal suckers—0.048 mm.

Average length of dorsal suckers—0.064 mm.

Average distance of genital atrium from anterior end of body—0.256 mm.

Average distance vitellarium extends into the cotylophore—0.48 mm.

No. of Testes—29.

Average length of one testis—0.112 mm.

Average width of one testis—0.192 mm.

### *Discussion.*

Paired dorsal structures apparently equivalent to the similar structures present in *M. agonostomi* have been recognised by Parona and Perugia in *M. alcedinis* and *M. canthari*, and by Brown in *M. centrodoni*. Parona and Perugia in their specimens described these structures as the paired openings of the rather wide, conspicuous, paired vaginal ducts. This view Brown is disinclined to believe, considering that Parona and Perugia have overlooked the vaginal ducts and probably their common pore. Brown stressed the single vaginal aperture, since *M. sillaginae* from Victoria, described as having paired vaginal apertures, was not then known. *M. agonostomi* has been observed in a living condition, and here the wide ducts were observed as being vitelline ducts which ran ventrally to the pair of dorsal suckers from the lateral fields of the vitellarium. From a preparation *in toto*, vaginal canals were observed to pass anteriorly from the inner margin of the vitelline ducts. Unfortunately, these could not be traced along their entire course, and hence it was not determinable whether they united to open

TABLE I.

Species.	Body Length.	Body Width.	Distance Intestine passes into C'otylophore.	No. of Posterior Suckers.	Breadth of Suckers of C'otylophore.	Oral Suckers with or without Septa.	Size of Oral Suckers.	No. of Testes.	Size of Testes.	Hooks of Genital Armature.	Size of Spines of Genital Armature.
<i>M. magilis</i> ...	6 mm. to 10 mm.	1.1 mm.	Terminates at base	25 prs.	.07 mm. to .09 mm.	with	0.090 mm. x 0.063 mm.	40	0.112 mm.	35 hooks in complete circle.	0.02 mm.
<i>M. agonostomi</i> ...	3.84 mm.	1.04 mm.	0.56 mm.	34 prs.	.096 mm.	without	0.096 mm. x 0.048 mm.	29	0.112 mm. x 0.192 mm.	34 hooks as in Fig. 3.	0.014 mm. to 0.016 mm.

by a common vaginal pore or if they opened by paired pores. Probably a similar condition to this exists in *M. alcedinis* and *M. canthari*. *M. centrodoni* appears to present a different condition with the vitelline ducts connecting to the vitellarium at a considerable distance posterior to the region where the dorsal suckers occur.

#### *General Remarks.*

A specimen of *M. agonostomi* was removed alive from the gills of its host, *Agonostomus forsteri*, during the afternoon of June 16, 1942. This was placed in a dish of water from the Swan River (approximately equivalent to seawater) and it performed quite active movements. This parasite remained alive and very active for four days, and then followed a period with a marked decrease in its activity and it died on June 21, 1942. Similar experiments were performed and this was found to be the average length of time which the parasite stayed alive away from its host. On each occasion usually about twenty eggs were laid during the period the parasite lived.

#### *Affinities.*

*M. agonostomi* seems to find its closest relationship in *M. mugilis* (Vogt) from the gills of *Mugil cephalus*. For the comparison the description of Yamaguti (1938), was employed and also that by Parona and Perugia (1890). *Microcotyle agonostomi* seems to have a general configuration agreeing with that of *M. mugilis*, although the cotylophore of *M. agonostomi* is not distinctly demarcated as it appears to be in *M. mugilis*. However, they differ in a considerable number of details, the most important of which is the presence of dorsal suckers in *M. agonostomi*, and a divergent type of genital armature. *M. agonostomi* varies also in the conspicuous type of vitelline ducts. The further differences are best shown in Table 1.

*M. agonostomi* has in common with *M. alcedinis* Parona and Perugia, *M. canthari* Parona and Perugia and *M. centrodoni* Brown a pair of dorsally situated suckers in the anterior half of the body. *M. sciaenicola* Murray has a pair of genital suckers with small simple hooks. These are the only species of *Microcotyle* with such structures. However, the general shape, etc., of these species immediately eliminate them as having a close relationship with *M. agonostomi*.

#### ***Microcotyle parasillaginae* sp. nov. (Pl. II, Fig. 5.).**

*Habitat*: Gills.

*Host*: *Sillaginodes punctatus*, the Spotted Whiting.

*Locality*: Albany, Mandurah.

#### *Occurrence.*

During the period from the middle of April until the beginning of September, 1942, the gills of sixty-four *Sillaginodes punctatus* were examined, and from eight of these fish *Microcotylids* were obtained. The parasites were never found singly, the lowest number found on one fish being three and the maximum ten. Although whiting from Mandurah were examined on fifteen different occasions, only once were the parasites found, and that was on 11th July, 1942. Fish from Albany were examined only on four occasions, and on two of these, one in April and one in July, the parasites were found. This seems to indicate that the parasites are of much more frequent occurrence in Albany waters than in the Mandurah estuary.



*General Structure.*

*Microcotyle parasillaginae* is a small, elongated, slender form, having, when preserved, an average length of 2.15 mm., only in one case reaching a maximum length of 2.56 mm. Greatest width, 0.368 mm., was about half way along the body, and the body tapers gradually both anteriorly and posteriorly. Across the region of the oral suckers the width is 0.144 mm. The cotylophore, which is demarcated from the rest of the body, averages in length 0.824 mm., with the maximum being 1.12 mm., and hence occupying usually a little more than one-third of the total length. Width of the anterior margin of the cotylophore is 0.16 mm., and the width of the posterior margin 0.08 mm. The posterior suckers along either margin of the cotylophore each has a similar structure with a chitinous framework (Pl. II, Fig. 6). Altogether the number of suckers present varied from 25 to 27 pairs and in one exceptional case numbered 29 pairs. These suckers were all constantly the same size, with a width of .064 mm. and a length of 0.32 mm.

Situated within the buccal cavity are anterior oval oral suckers. Each sucker has a width of 0.08 mm. and a length of 0.048 mm., and each possesses an oblique septum. The pharynx is situated close behind the oral sucker and posteriorly to this is the genital atrium. This is 0.224 mm. from the anterior end and possesses an armature of small hooks arranged in a circle, as well as the hooks which are situated on the penis (Pl. II, Fig. 7).

*Alimentary Canal.*

The anteriorly situated mouth opens into the large buccal cavity in which the oral suckers are present. This continues into the pharynx, the width of which is 0.032 mm., and the length 0.048 mm. Oesophagus passes posteriorly for 0.16 mm. and bifurcates immediately posteriorly to the genital atrium.

*Nervous System.*

The brain is situated dorsally to the oesophagus, shortly posterior to the pharynx region. From it a pair of anterior nerves pass anteriorly and a larger pair posteriorly.

*Reproductive Systems.*

*Male.*—There are fourteen testes situated in the posterior third of the body length, anterior to the cotylophore. These testes are subquadrangular in shape and are of a more or less constant form, the average size being .08 mm. by 0.064 mm. The vas deferens winds anteriorly as a thick-walled, wide duct, medianly situated. This terminates in a penis 0.048 mm. long, which is set round its base with several small spines. It is situated in the genital atrium which is surrounded by a small circle of hooks.

*Female.*—The ovary is situated in the median field immediately anterior to the testes. It commences in a position close to the testes and passes anteriorly to form a broad curve, and passes posteriorly once again. Paired vitellaria occupy lateral fields and are 0.268 mm. from the anterior end of the parasite, and a short distance posteriorly to the genital atrium. Lateral vitelline fields extend posteriorly into the cotylophore for 0.4 mm. They unite close behind the testicular field. A pair of vitelline ducts arises on either side at 0.48 mm. from the anterior end. These ducts are 0.096 mm. long, and unite posteriorly as the common vitelline duct, 0.144 mm. long. These vitel-

line ducts have the usual Y-shape. Uterus is a thin-walled straight tube passing anteriorly in the middle field, to open into the genital atrium immediately behind the male aperture.

*Summary of Specific Characters.*

Average length of body—2.15 mm.

Average length of cotylophore—0.824 mm.

Average length of rest of body anterior to cotylophore—1.326 mm.

Average width of oral suckers—0.08 mm.

Average length of oral suckers—0.048 mm.

Average width of suckers of cotylophore—0.064 mm.

Average length of suckers of cotylophore—0.032 mm.

Number of suckers on cotylophore—25-27 pairs.

Average distance of genital atrium from anterior end of body—0.224 mm.

Distance vitellarium extends into cotylophore—0.4 mm.

Number of testes—14.

Average size of testes—0.08 mm. x 0.064 mm.

Length of penis—0.048 mm.

Penis bears small spines.

*Affinities.*

*M. parasillaginae* is strikingly like *M. sillaginae* in general appearance and structure. However, the sizes of the various structures were so constantly different that it was considered necessary to create the new species, *M. parasillaginae*. The penis in *M. parasillaginae* was not situated on a papilla as in *M. sillaginae*, and unlike the latter it had round its base a number of small hooks. The other differences are best shown in Table II.

***Microcotyle arripis*, sp. nov. (Pl. III, Fig. 8.).**

*Habitat*: Gills.

*Host*: *Arripis georgianus*.

*Locality*: North Beach, Swan River, Mandurah, Bunbury, Busselton, Albany, Woodman's Point, Scarborough, Whitford's Beach.

*Occurrence.*

From April to August, 1942, 50 *Arripis georgianus* were examined for gill parasites and 51 Microcotylids were found. The average number of parasites obtained from one fish was two, that is, by not taking into consideration the fish with no parasites. The maximum number of parasites actually recovered from one fish was four. These parasites were very delicate and extremely difficult to handle. Owing to the diverse localities from which the fish were obtained, it is difficult to estimate whether or no parasites are more plentiful at any particular period of the year. However, indications seem to show that the most parasites were obtained during April and May.

TABLE II.

Species.	Total Length.	Length of Cotylophore.	No. of Posterior Suckers.	Size of Posterior Suckers.	Size of Oral Suckers.	No. of Testes.	Size of Penis.	Intestinal Bifurcation.	Atrium Armature.
<i>M. sillaginæ</i>	4 mm.	Half length or more	32 prs.	0.05 mm. to 0.07 mm. in width	0.08 mm. X 0.04 mm.	11	0.027 mm. plus papilla	Anterior to genital atrium	Absent
<i>M. parasillaginæ</i>	2.15 mm.	0.824 mm. approx. one third length	25-27 prs	Constantly 0.064 mm.	0.08 mm. X 0.048 mm.	14	0.018 mm. no papilla	Behind genital atrium	Present



*General Structure.*

The parasite varies from a somewhat oval form to a more elongated shape. Average total length is 2.08 mm., with a maximum width of 0.72 mm. across about the middle of the body. Body tapers both posteriorly and anteriorly. Across the genital atrium the width is 0.24 mm., while more anteriorly, across the region of the oral suckers, it measures 0.08 mm. Cotylophore is 0.528 mm. long, thus occupying approximately a quarter of the total length. Cotylophore across its anterior margin measures 0.48 mm. and its posterior edge is 0.08 mm. wide. Cotylophore is not sharply differentiated from the body proper, but appears as a continuation which bears along its lateral margins a row of suckers on each side (Pl. III, Fig 8). Each of these is supported by a chitinous framework and they are all of a similar structure (Pl. III, Fig. 9). All these suckers are approximately of equal size on one parasite, the average size being 0.032 mm. long and 0.048 mm. wide. There are 35 pairs of these posterior suckers.

Situated within the buccal cavity is a pair of oral suckers, which are not very conspicuous. Each has a width of 0.064 mm. and a length of 0.016 mm. No transverse septum is present. Pharynx is situated very close to the oral suckers. Some little distance behind the pharynx is the ventrally situated genital atrium with its armature of spines (Pl. III, Fig 10). Width of this armature is 0.128 mm., and its length 0.08 mm. Spines of the armature are conical and 0.012 mm. in length.

*Alimentary Canal.*

Mouth aperture situated at the anterior end of the body and leads into the buccal cavity in which the pair of buccal suckers are situated. From this leads the circular muscular pharynx, which has a diameter of 0.048 mm., and which leads into the oesophagus posteriorly. Oesophagus has a total length of 0.256 mm., and it bifurcates a little distance behind the genital atrium, at a total distance of 0.352 mm. from the anterior end of the body. Numerous branches pass from the main lateral intestinal canals. These branches extend over the lateral fields of the body. Intestine extends for 0.24 mm. into the cotylophore.

*Excretory System.*

Along either side of the body is a longitudinal duct running ventrally to the alimentary canal. Each duct continues to the extreme posterior end of the body.

*Nervous System.*

Brain complex is rectangular in shape, enveloping the oesophagus dorsally and lying at a distance of 0.16 mm. from the anterior end of the body. Two pairs of anterior nerve cords pass forwards. Two pairs of posterior nerve cords also pass backwards, the outer pair being the better developed pair of nerves.

*Reproductive Systems.*

*Male.*—In the posterior quarter of the body, anterior to the cotylophore region are 23 testes. These are of irregular shape, and fit closely against one another, in a pavement manner. The average size of each testis

TABLE III.

Species.	Total Length.	Length of Cotylophore.	Number of Posterior Suckers.	Size of Posterior Suckers.	Oral Sucker with or without Septum.	Size of Atrial Spines.	Number of Testes.	Distance Vitellarium extends into Cotylophore.
<i>M. arripis</i> ...	2.08 mm.	0.528 mm.	35 prs.	0.032 mm. x 0.048 mm.	without	0.012 mm.	23	0.08 mm.
<i>M. caudata</i> ...	3.2 mm. or less	0.8 mm.	25 prs.	0.045 mm. to 0.08 mm.	with	0.01 mm.	about 23	...
<i>M. truncata</i> ...	3.3 mm.	very short	10 prs.	0.055 mm. x 0.072 mm.	?	0.13 mm.	Numerous	Extends all the way into the Cotylophore.
<i>M. fusiformis</i> ...	2.0 mm.	1 mm.	30-33 prs.	0.046 mm. x 0.065 mm.	with	0.067 mm.	about 15	Extends long way into Cotylophore.
<i>M. sebastis</i> ...	5.5 mm.	1.83 mm.	29 prs.	0.068 mm. x 0.128 mm.	with	0.017 mm.	about 40	Does not extend into Cotylophore.
<i>M. sciaenicola</i> ...	6.64 mm.	2.213 mm.	Appear to be over 40 prs.	?	?	...	Small and numerous	Extends very little into Cotylophore.

is approximately 0.048 mm. long and 0.096 mm. wide. The vas deferens is a thick-walled, fairly wide duct, which follows a sinuous course to the genital atrium.

*Female*.—The medianly situated ovary, when viewed dorsally, is somewhat S-shaped. It commences in a region closely applied to the most anterior testes, bends sharply on itself, and then by a winding course runs forwards, sweeps to the left and loops back to the right. The course it then traces is dorsally situated to the first portion. It passes back and joins the common vitelline duct. Maximum length of the ovary is 0.368 mm. Vitellarium commences 0.352 mm. from the anterior end of the body. It occupies both lateral fields and extends for 0.32 mm. into the cotylophore, where the two sides join, posteriorly to the testes. At 0.80 mm. from the extreme anterior end of the body, there arises from each lateral vitelline field a vitelline duct. Each of this pair of vitelline ducts passes for 0.24 mm. posteriorly, and then they unite into a common vitelline duct, 0.152 mm. long. In the region where the oviduct and common vitelline duct join, the genito-intestinal canal passes into the intestine. The receptaculum seminis is formed soon after the union of the oviduct and common vitelline duct. The uterus passes anteriorly as a thin-walled duct, situated in the central field, and proceeds straight to the genital atrium.

#### *Egg.*

The egg was seen only in the uterus, but the measurements made here were—length of egg 0.224 mm.; maximum width of egg 0.08 mm.; length of the longer appendage 0.48 mm. approximately; length of the shorter appendage 0.08 mm. approximately.

#### *Summary of Specific Characters.*

- Average length of body—2.08 mm.
- Average length of cotylophore—0.528 mm.
- Average length of rest of body anterior to cotylophore—1.452 mm.
- Average length of oral suckers—0.064 mm.
- Average width of oral suckers—0.016 mm.
- Number of suckers on cotylophore—35 pairs.
- Average width of suckers on cotylophore—0.048 mm.
- Average length of suckers on cotylophore—0.032 mm.
- Average distance of genital atrium from anterior end of body—0.24 mm.
- Distance vitellarium extends into cotylophore—0.08 mm.
- Number of testes—23.
- Average length of testis—0.048 mm.
- Average width of testis—0.096 mm.

#### *Affinities.*

*Microcotyle arripis* appears to be most nearly related to *M. caudata* Goto, *M. truncata* Goto, *M. fusiformis* Goto, *M. sebastis* Goto, *M. sciaenicola* Murray. Although showing no marked affinities with any of these, the closest relationship seems to be between *M. arripis*, *M. fusiformis* and *M. truncata*. The tabulated comparisons (Table III) clearly show the difference in these forms.



*Microcotyle temnodontis* sp. nov. (Pl. IV, Fig. 12.).

*Habitat*: Gills.

*Host*: *Temnodon saltator*.

*Locality*: Mandurah, Albany, Swan River, Bunbury.

*Occurrence*.

From April to August, 1942, 47 fish were examined and from their gills 148 Microcotylids were obtained. The average number of parasites for one fish was 3. The majority of fish obtained in the period were from Mandurah, and of these the parasites seemed to be most plentiful in June and July, with a sudden diminishing in abundance in August.

*General Structure*.

The parasite has an elongated form, being 2.72 mm. long and having a maximum breadth of 0.4 mm., at about centre of body and tapering gradually both anteriorly and posteriorly. Towards the anterior end, the body width is, in the region of the genital armature 0.152 mm. and across the region of the oral suckers 0.112 mm. wide. Cotylophore, which is distinctly demarcated from the rest of the body, is 0.72 mm. long, and across its most anterior border measures 0.4 mm., while the width of the posterior edge is 0.08 mm. Cotylophore occupies almost one-quarter of the total body length, the rest of the body having a length of 2.0 mm. Along either lateral border of the cotylophore is a row of suckers, each of which is of a similar structure and has a chitinous framework, as seen in (Pl. IV., Fig. 13). There are altogether 55 pairs of these posterior suckers and the average size of each is 0.016 mm. long and 0.032 mm. wide.

Lying in the buccal cavity at the anterior end of the body is a pair of conspicuous, practically circular oral suckers with a diameter of 0.048 mm. These suckers do not possess transverse septa. Lying closely behind the oral suckers is the pharynx and posteriorly again to this is the genital atrium with its conspicuous armature of simple spines (Pl. IV., Fig. 14). Genital armature is 0.08 mm. in diameter and lies entirely on the ventral surface. Spines of the genital armature are conical, being 0.008 mm. long.

*Alimentary Canal*.

At the anterior end of the body is the mouth, opening into a large buccal cavity containing the oral suckers. Leading from this is the oval pharynx 0.032 mm. long and 0.08 mm. wide, and this passes directly into the oesophagus which runs posteriorly for 0.24 mm., and the intestinal bifurcations diverge posteriorly to the genital armature, and at a total distance of 0.336 mm. from the anterior end of the body. From the main lateral intestinal canals are numerous ramifications, these being most obvious in the outer fields. The ramifications extend 0.08 mm. into the cotylophore.

*Excretory System*.

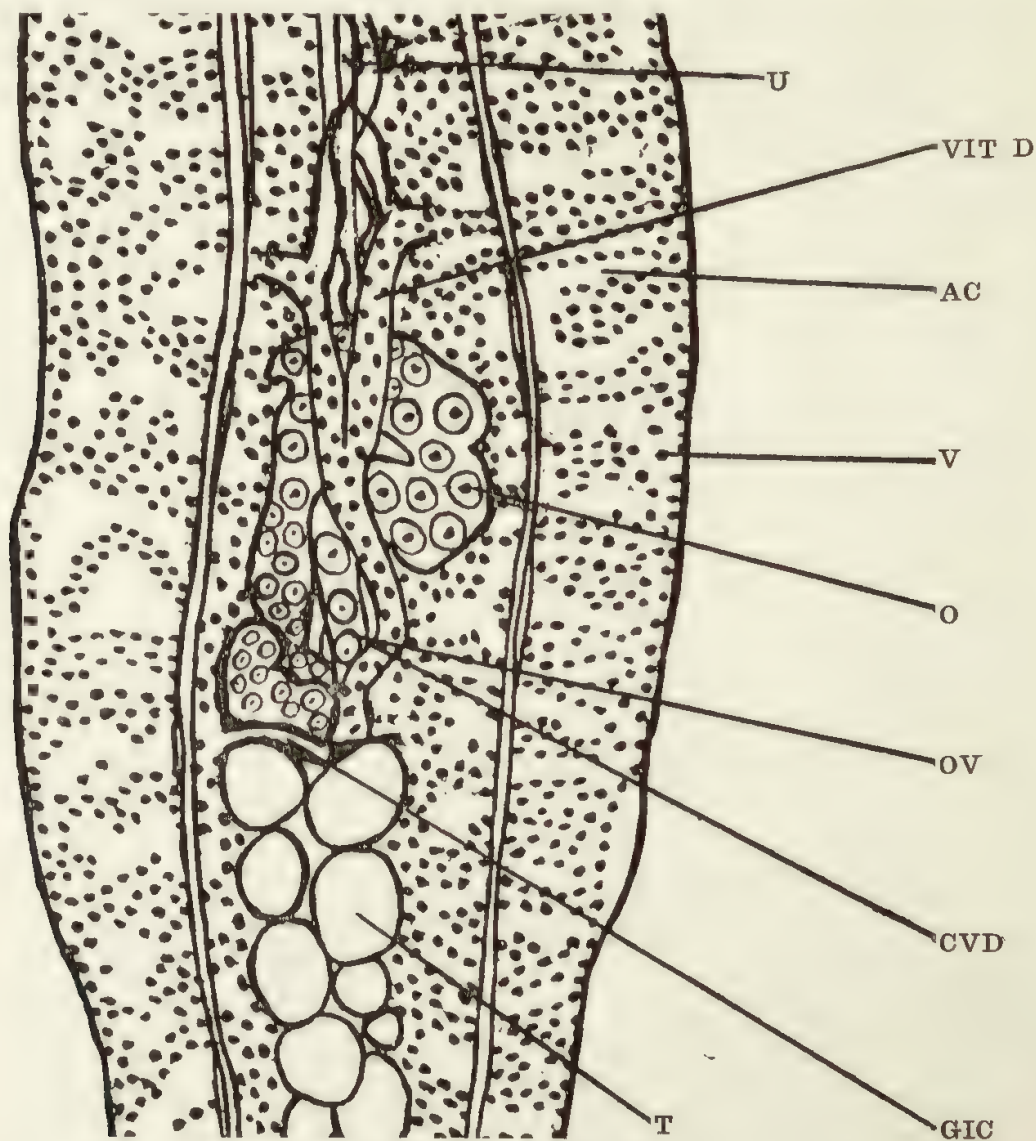
A main longitudinal duct runs along either side of the body ventrally to the intestinal canals. Each duct passes to the extreme posterior end of the cotylophore.

*Nervous System.*

The brain is a rectangular shaped structure 0.128 mm. from the anterior end of the body, dorsal to the oesophagus. A pair of anterior nerve cords arises from the front of the brain, and from the posterior edge arises a pair of posterior longitudinal nerve cords.

*Reproductive Systems.*

*Male.*—There are 21 testes, all of a circular to subcircular shape. These are situated in a field 0.48 mm. long in the posterior quarter of the body anterior to the cotylophore and between the vitellaria. The testes follicles at the anterior end are the larger, being on the average 0.064 mm. in diameter, while towards the posterior end each has a diameter of only 0.048 mm. The vas deferens is a wide, thick-walled duct tracing a sinuous course anteriorly, to open into the genital atrium.



Text Fig. 1.—*Microcotyle temnodontis* sp. nov.

*Female.* The ovary, which is median in position, commences close to the most anterior testes, passes forwards towards the right, swings to the left and curves slightly, and then passes straight back to be joined by the common vitelline duct. The single dorsal vaginal pore is best seen while the parasite is alive, and it lies immediately posterior to the genital armature, in the middle line. It has no armature around its aperture. Paired vaginal

TABLE IV.

Species.	Body Length.	Length of cotylophore.	No. of Posterior Suckers.	Breadth of Suckers of cotylophore.	Oral Suckers with or without septa.	No. of Testes.	Size of spines of genital armature.
<i>M. temnodontis</i> ... ..	2.72mm.	0.72mm.	55prs.	0.032mm.	without	21	0.008mm.
<i>M. australiensis</i> ... ..	4.00mm.	1.40mm.	Diagram shows as numerous	?	?	25	?
<i>M. sebastis</i> ... ..	5.50mm.	1.83mm.	29 prs.	0.068mm. to 0.123mm.	with	40	0.017mm.
<i>M. elegans</i> ... ..	4.00mm.	1.30mm.	50 prs.	0.040mm. to 0.068mm.	with	27	0.005mm.
<i>M. victorise</i> ... ..	4.82mm.	1.20mm. approx.	21 prs.	?	with	18-22	0.045mm. to 0.009mm.
<i>M. hiatalae</i> ... ..	3.50mm.	...	23 prs.	?	?	15	0.015mm. to 0.018mm



canals join the vitelline ducts and run anteriorly for a short distance and unite to form a median duct leading to the vaginal pore. Vitellarium begins 0.32 mm. from the anterior end of the body and occupies both lateral fields and extends into the cotylophore for 0.08 mm. At 1.12 mm. from the anterior end of the vitellarium a vitelline duct arises on either side. These ducts form the typical Y-shape. Each of the paired ducts is 0.08 mm. long, and they join in the middle line and pass posteriorly for 0.16 mm. as the common vitelline duct. It joins the oviduct and the genito-intestinal canal passes to the right intestinal branch. The uterus is a thin-walled straight tube situated in the central field, lying dorsally to the vitelline ducts and passing forwards to open into the genital atrium. (Text Fig. 1.)

### *Egg.*

The eggs of *Microcotyle temnodontis* are very elongated, being 0.294 mm. long and having a maximum width of 0.042 mm. Each has a very long filament at either end, that of one end being 1.105 mm. long and that of the other end approximately 0.42 mm. long (Pl. IV., Fig. 15).

### *Summary of Specific Characters.*

Average length of body—2.72 mm.

Average length of cotylophore—0.72 mm.

Average length of rest of body anterior to cotylophore—2.0 mm.

Average diameter of oral suckers—0.48 mm.

Average length of suckers of cotylophore—0.016 mm.

Average width of suckers of cotylophore—0.032 mm.

Number of suckers on cotylophore—55 pairs.

Average distance of genital atrium from anterior end of body—0.288 mm.

Distance vitellarium extends into cotylophore—0.08 mm.

Number of rounded testes—21.

Average diameter of testes—0.056 mm.

### *General Remarks.*

A specimen of *M. temnodontis* was removed from the gills of its host, *Temnodon saltator* in the afternoon of June 23, 1942. Since it showed signs of life it was placed in a dish of water from the Swan River (approximately equivalent to seawater). This specimen was still alive in the late afternoon of June 24, 1942, but it died some time during the ensuing night. This specimen laid approximately 20 eggs. From the manner in which the eggs stayed attached to the parent it seemed that, if the eggs were produced while the parasite was still attached to the host, the eggs could possibly stay fixed somewhere in the gill chamber, until they hatched. The average length of time which these parasites lived after being detached from their host and placed in river water, as above, was 1½ days.

### *Affinities.*

Woolcock (1936) related *Microcotyle victoricae* to the group of Microcotylids:—*M. australiensis* MacCallum (1931), *M. sebastis* and *M. elegans* Goto (1895); *M. bassensis* Murray (1931) and *M. hiatalae* Goto (1899). It appears that *M. temnodontis* is closely related to this group.

Several of these species, in general appearance, rather closely resemble *M. temnodontis*, but differences in length and the measurements, etc., of various parts occur, as is shown in the Table IV.

***Microcotyle odacis*, sp. nov.** (Pl. V, Fig. 16.).

*Habitat*: Gills.

*Host*: *Odax semifasciatus*, Weedy Whiting.

*Locality*: Albany.

*Occurrence*.

The material used for this description was obtained from Albany in April, 1941. About 15 specimens were obtained from three fish at the one examination. Hence it seemed that the parasites were of frequent occurrence in this locality, at this particular period.

*General Structure*.

*Microcotyle odacis* is an elongated form, being symmetrical and having uniformly smooth margins. Average length is 3.28 mm. and the maximum width is 0.512 mm. at about the middle of the length. Across the genital atrium region the width is 0.224 mm., while across the oral sucker portion it measures 0.144 mm. For the posterior quarter of its length, the cotylophore, which is 0.88 mm. long, is distinctly separated from the rest of the body. Cotylophore tapers gradually posteriorly, being approximately the shape of an elongated triangle. Its anterior margin measures 0.432 mm., and the posterior is 0.128 mm. wide. Along each lateral margin it bears a series of small suckers which number 28 on the right side and 30 on the left side. These suckers are all of a similar structure, and each is supported by a chitinous framework (Pl. V., Fig 17). All the suckers of the cotylophore are of approximately equal size, being 0.064 mm. wide and 0.048 mm. long.

At the anterior end of the body, in the buccal cavity, is a pair of muscular suckers 0.08 mm. in diameter. Each of these suckers possesses a transverse septum, which is obliquely placed to the longitudinal axis of the body of the parasite. Situated closely behind the oral suckers is the pharynx, which has a diameter of 0.048 mm. On the ventral surface, 0.272 mm. from the anterior end, is the genital atrium with its armature of small simple hooks, each 0.016 mm. long. This genital armature has a maximum width of 0.112 mm. and a maximum length of 0.112 mm. (Pl. V., Fig. 18).

*Alimentary Canal*.

At the anterior end of *Microcotyle odacis* is the mouth which opens into the large buccal cavity, from which passes the subcircular pharynx with a diameter of 0.048 mm. This continues into the oesophagus which has a total length of 0.24 mm. The intestinal bifurcation occurs immediately posterior to the genital atrium and 0.40 mm. from the anterior end of the body. The main longitudinal intestinal canals then pass along each lateral field and numerous side branches are given off on both sides. These branches pass into the cotylophore for 0.312 mm.

*Nervous System.*

At 0.208 mm. from the anterior end of the body, the brain is situated above the oesophagus. From this brain a pair of small anterior nerves passes to the front of the body, while posteriorly a pair of longitudinal nerves is given off as well as an outer pair of shorter nerves.

*Reproductive Systems.*

*Male.*—There are 14 testes with an average size of 0.112 mm. by 0.096 mm., which are situated in a paired manner in the posterior region of the body, and occupying a little more than a quarter of the length of the body (omitting the cotylophore). The testes lie completely within a field enclosed by the vitellaria. The vas deferens passes forwards and the male genital pore is situated in the genital atrium.

*Female.*—The ovary is situated in the median field immediately anterior to the testes. The ovary has its origin here and passes forwards and curves round to pass posteriorly again. Total length of the ovary is 0.32 mm. Vitellaria are situated laterally, being present 0.448 mm. from the anterior end of the body, where the lateral fields converge. These fields meet posteriorly behind the testes and extend for 0.312 mm. into the cotylophore. The transverse vitelline ducts commence at 0.96 mm. from the anterior end of the vitelline follicles and pass posteriorly as paired ducts for 0.112 mm. and they join as the common vitelline duct which runs backwards for 0.16 mm. Thus the typical Y formation of the vitelline ducts is formed. The genito-intestinal canal communicates with the right intestinal canal. In the median field the thin-walled uterus passes anteriorly to open in the genital atrium.

*Egg.*

This was seen only in the uterus. It has an oval form with appendages at both poles. Each egg has a length of 0.152 mm. and a maximum width of 0.096 mm. The appendages are approximately 0.128 mm. and 0.848 mm. long respectively. (Pl. V., Fig. 19).

*General Remarks.*

The specimens were received in a preserved condition and not collected fresh by the author.

*Summary of Specific Characters.*

Average length of body—3.28 mm.

Average length of cotylophore—0.88 mm.

Average length of rest of body anterior to cotylophore—2.40 mm.

Average diameter of oral suckers—0.08 mm.

Number of suckers on cotylophore—28.30.

Average length of suckers on cotylophore—0.048 mm.

Average width of suckers on cotylophore—0.064 mm.

Average distance of genital atrium from anterior end of body—0.272 mm.

Distance vitellarium extends into the cotylophore—0.312 mm.

Number of testes—14.

Average size of testes—0.112 mm. by 0.096 mm.



TABLE V.

Species.	Total Length.	Length of Cotylophore.	Number of Posterior Suckers.	Size of Posterior Suckers.	Oral Sucker with or without Septum.	Size of Atrial Spines.	Number of Testes.	Distance Vitellarium passes into cotylophore.
<i>M. odaris</i> ... ..	3.28mm.	0.88mm.	28 and 30	0.048mm. x 0.064mm.	with	0.016mm.	14	0.312mm.
<i>M. elegans</i> ... ..	4.00mm.	1.30mm.	50 prs.	Breadth 0.040mm. to 0.068mm.	with	0.005mm. conical	27	Extends into cotylophore.
<i>M. bassensis</i> ... ..	5.80mm. to 6.30mm.	1.90mm. to 2.10mm.	50-55 pairs	2 rows	with 2 rows minute hooks	0.009mm.	30-36 small	Extends into cotylophore.
<i>M. australiensis</i> ... ..	5.60mm.	1.86mm.	Not stated. Appears to be over 50 pairs.	...	...	...	8-9 unpaired	Extends into cotylophore.
<i>M. pagrosomi</i> ... ..	5.20mm.	1.73mm.	Not stated. Appears to be over 50 pairs.	...	with 1 row minute hooks	...	small and numerous	One lateral field extends into cotylophore.

*Affinities.*

*M. odacis* seems to be quite a distinct form, bearing no very close relationship to any other species. The species of *Microcotyle* most nearly allied to *M. odacis* appear to be *M. elegans* Goto, *M. bassensis* Murray, *M. australiensis* Murray, and *M. pagrosomi* Murray. However, even from these forms, *M. odacis* is very distinct in various features. These divergencies are best shown in Table V.

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## KEY TO LETTERING OF FIGURES.

A.N.C.	Anterior Nerve Cord.	O.S.H.	Hooks of Oral Sucker.
B.	Brain.	Ov.	Oviduct.
B.C.	Buccal Cavity.	P.	Penis.
C.	Cotylophore.	Ph.	Pharynx.
C.V.D.	Common Vitelline Duct.	P.N.C.	Posterior Nerve Cord.
D.S.	Dorsal Sucker.	P.S.	Posterior Sucker.
E.	Egg.	R.S.	Receptaculum Seminis.
E.C.	Excretory Canal.	S.O.	Shell Gland and Ootype.
G.A.	Genital Atrium.	T.	Testes.
G.H.	Genital Hook.	T.S.	Transverse Septum.
G.I.C.	Genito-Intestinal Canal.	U.	Uterus.
I.	Intestine.	V.	Vitellarium.
L.P.	Lateral Projection.	V.C.	Vaginal Canal.
M.	Mouth.	V.D.	Vas deferens.
O.	Ovary.	Vit. D.	Vitelline Duct.
Oes.	Oesophagus.	V.P.	Vaginal Pore.
O.S.	Oral Sucker.		

## EXPLANATION OF PLATE I.

*Microcotyle agonostomi*, sp. nov.

- Fig. 1.—Whole specimen.  
 Fig. 2.—Posterior Sucker Skeleton.  
 Fig. 3.—Armature of Genital Atrium.  
 Fig. 4.—Egg.

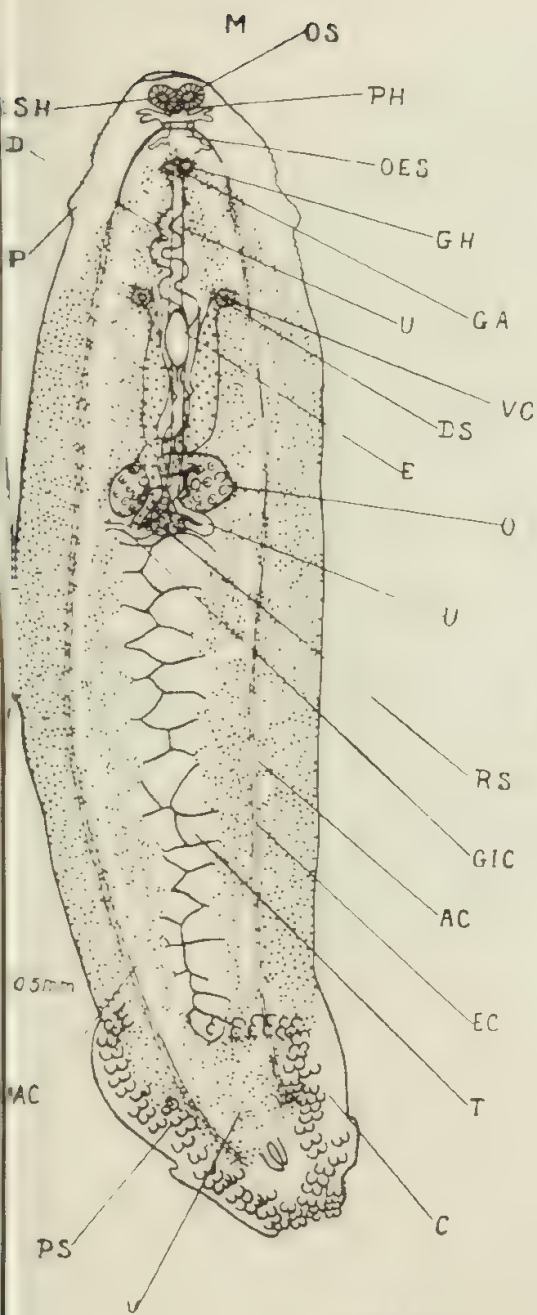


FIG 1.



FIG 2.

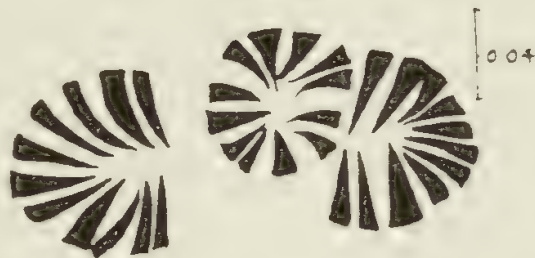


FIG 3.

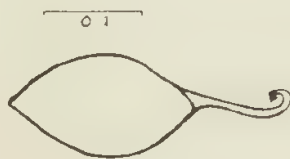


FIG 4.



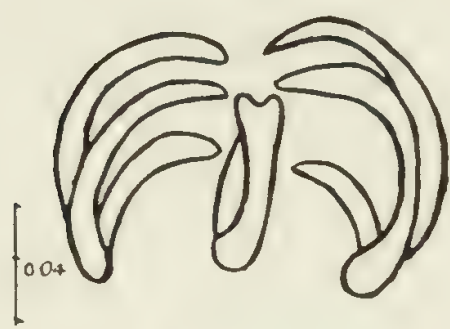
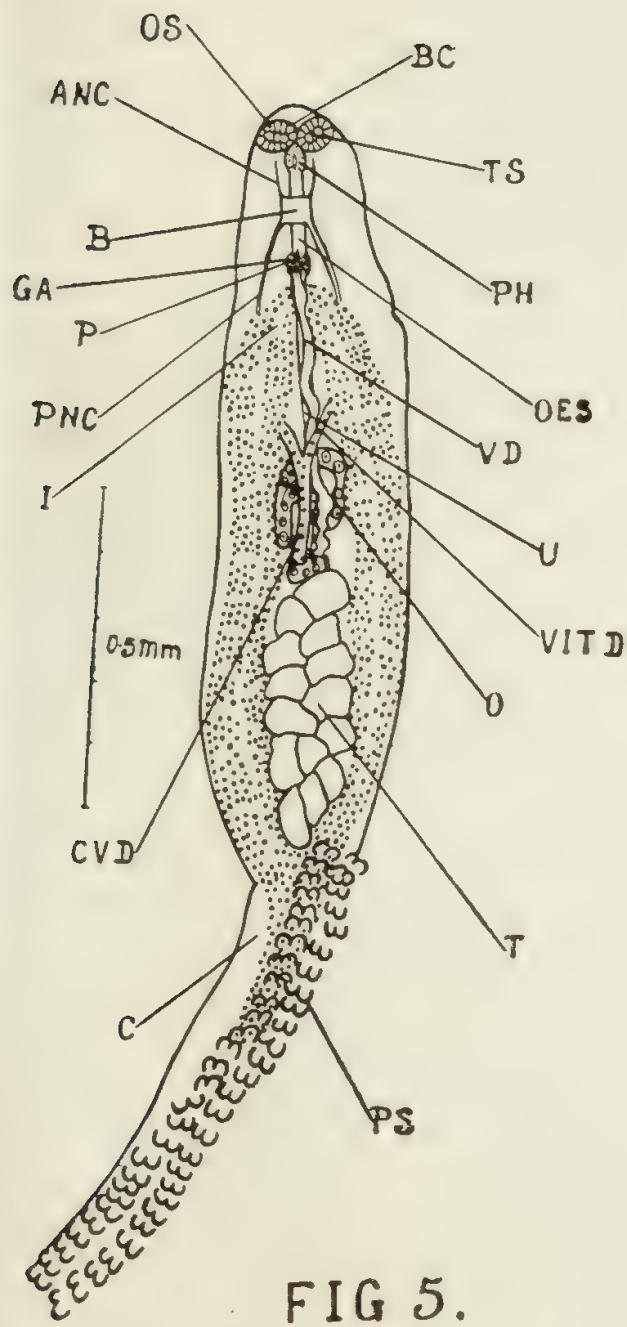
## EXPLANATION OF PLATE II.

*Microcotyle parasillaginae*, sp. nov.

Fig. 5.—Whole specimen.

Fig. 6.—Posterior Sucker Skeleton.

Fig. 7.—Penis and armature of Genital Atrium.



## EXPLANATION OF PLATE III.

*Microcotyle arripis*, sp. nov.

Fig. 8.—Whole specimen.

Fig. 9.—Posterior Sucker Skeleton.

Fig. 10.—Armature of Genital Atrium.

Fig. 11.—Egg.



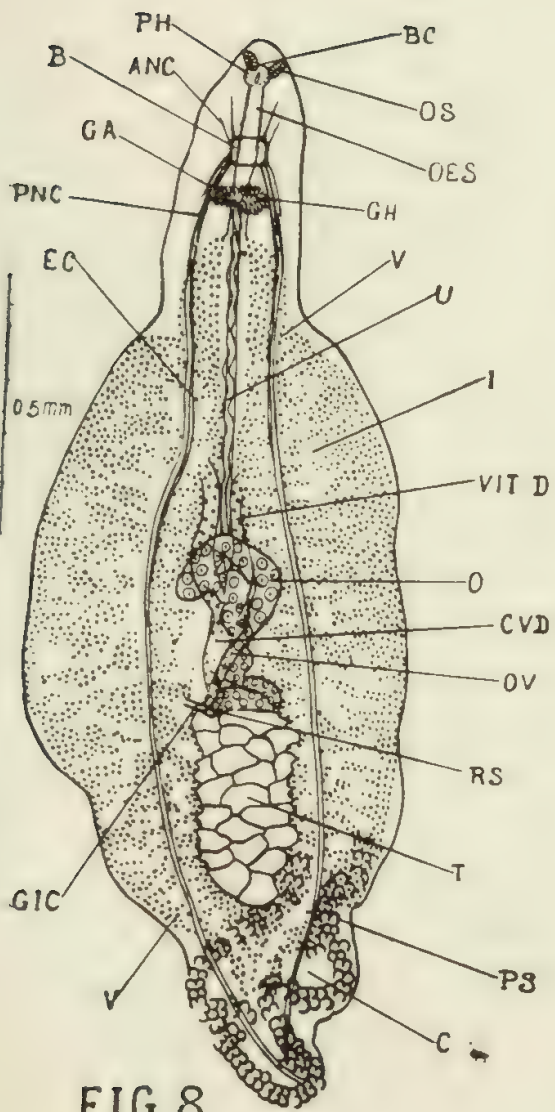


FIG 8.

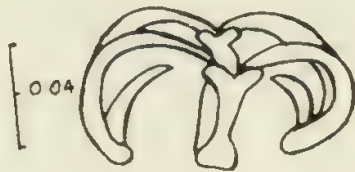


FIG 9.

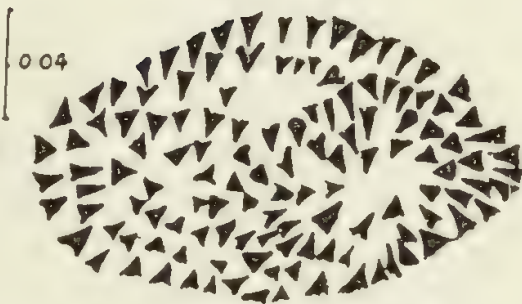


FIG 10.

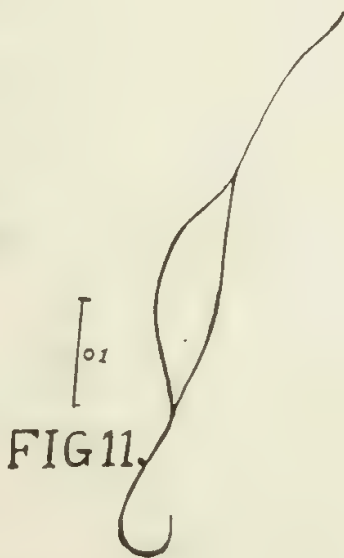


FIG 11.

## EXPLANATION OF PLATE IV.

*Microcotyle temnodontis*, sp. nov.

Fig. 12.—Whole specimen.

Fig. 13.—Posterior Sucker Skeleton.

Fig. 14.—Armature of Genital Atrium.

Fig. 15.—Egg.

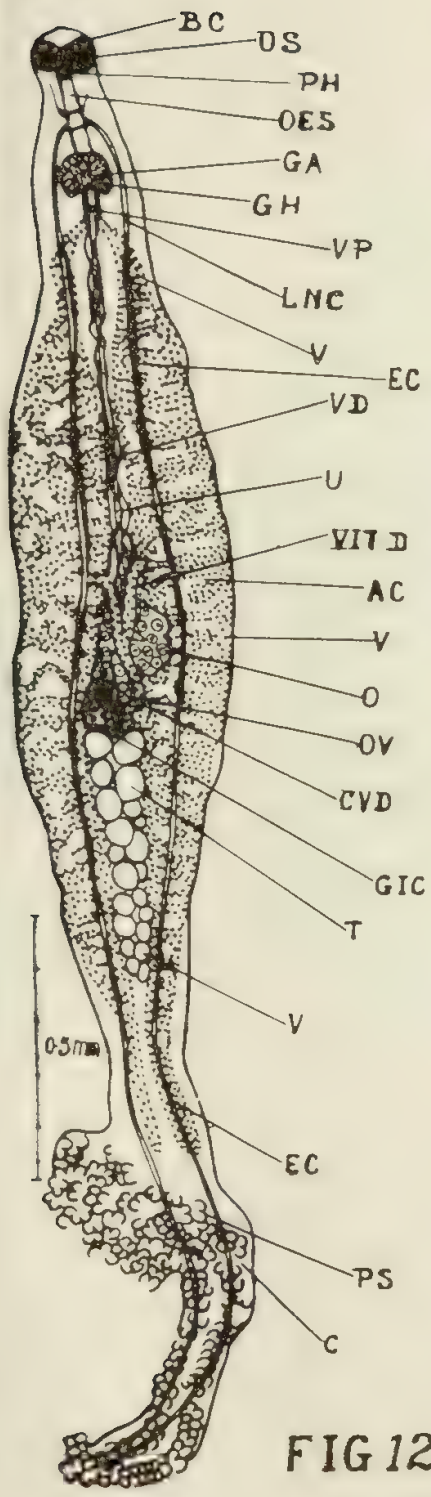


FIG 12.

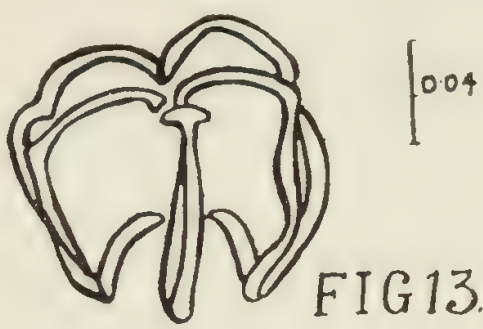


FIG 13.



FIG 14.

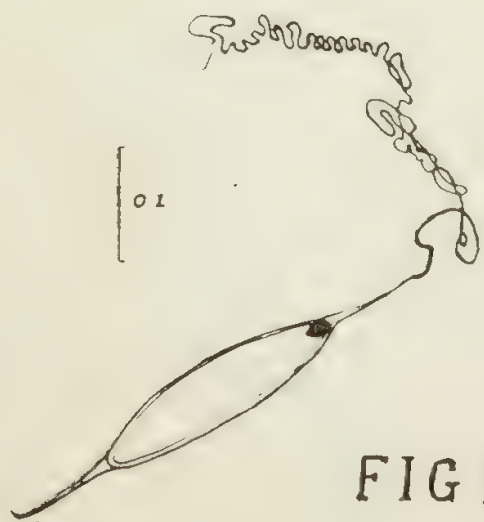


FIG 15.



## EXPLANATION OF PLATE V.

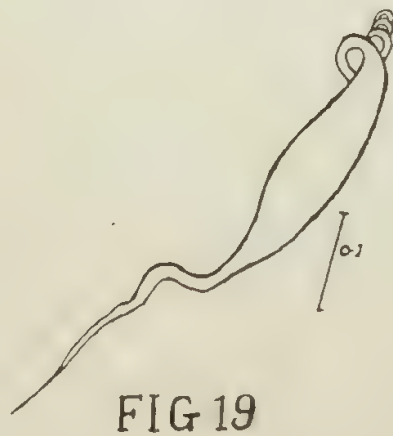
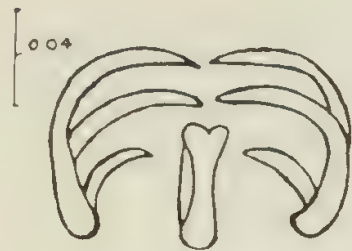
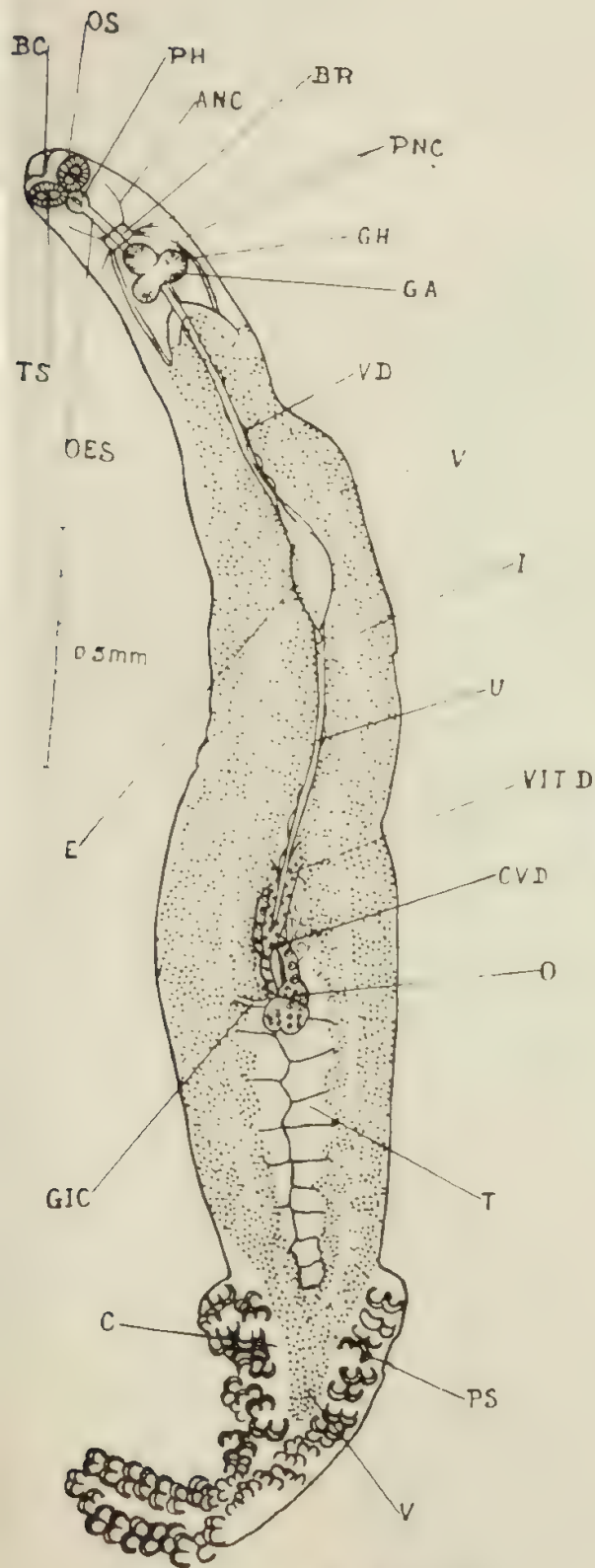
*Microcotyle odacis*, sp. nov.

Fig. 16.—Whole specimen.

Fig. 17.—Posterior Sucker Skeleton.

Fig. 18.—Armature of Genital Atrium.

Fig. 19.—Egg.







## 7.—GRANITIC ROCKS FROM CANNING DAM

by

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Read 9th March, 1943.

### INTRODUCTION.

The Darling Range in the vicinity of Perth is made up largely of a granitic complex of granite gneisses, migmatites (hybrid gneisses) and massive granites, all of which are traversed by aplites, pegmatites, and quartz veins, and by still later basic intrusives which vary in character from quartz diorites to epidiorites. The granitic rocks in places show faint traces of gneissic structure but the nature of this granite complex is largely obscured by the weathering of rock outcrops and the accumulation of weathering products and is not fully realised until freshly broken exposures in quarries are available for examination.

Recent work on these granitic rocks as exposed at Armadale (Prider, 1941), and Cardup (Thomson, 1941) indicates that there were at least two distinct phases in the formation of this complex:—(i) a period of granitisation or migmatisation which yielded hybrid granite gneisses from a pre-existing basic igneous terrain and (ii) the intrusion of a later massive granite with its associated end phase intrusions of aplite, pegmatite and vein quartz. An account of the geology of an area in the vicinity of Gosnells recently published by Davis (1941) indicates that in that locality only the later massive granite is developed. An earlier paper by Clarke and Williams (1926) which describes the geology of areas near Darlington and Roleystone, gives information regarding the granitic rocks of these areas from which it appears (loc. cit. p. 167) that at Darlington only the younger massive granite is developed while at Roleystone the older granite gneisses containing "biotitic segregations" (which are undoubtedly the equivalent of the basic xenoliths in the Armadale hybrid gneisses) are predominant, although it was considered at that time that the rocks of Darlington and Roleystone were probably of a single petrological unit showing wide variations in character from place to place. Fletcher and Hobson (1932) have described granitic rocks from a northerly extension of this mass at Upper Swan but only recognise one type of granite in this locality. A preliminary re-examination of some of these rocks by the author has indicated, however, that further work in this locality may yield results of interest so far as the northerly extension of the granitic complex is concerned. Miles (1938, p. 28) has noted that granitic rocks south of Chittering, which are very similar to the granites of the Darlington area, are intrusive into the older metasedimentary Chittering Series (loc. cit. p. 27) and these probably represent the most northerly extension of the granitic complex in the Darling Range.

At Canning Dam (which is situated twenty miles south-east from Perth) the two main phases of the formation of the granitic complex are very distinctly seen in the quarry opened up in 1933 for concrete aggregates used in

the construction of the dam. Previous geological work in this neighbourhood is confined to two geological reports, one by Campbell (1904) which contains a geological map of the Canning River valley and the other by Feldtmann (1916) dealing with the rocks in the vicinity of the dam site—Feldtmann notes the great variation in structure and mineralogy of the granites but does not give any detailed descriptions of the rocks, of which only natural exposures were available at that time.

### THE GRANITIC COMPLEX IN THE CANNING DAM QUARRY.

The exposures in the Canning Dam quarry which is situated approximately 300 yards south-west from the dam are similar in many respects to those in the road board quarry at Armadale (Prider, 1941, p. 29) and the granitic complex in this locality is essentially the same as has already been described at Armadale. In view, however, of the excellence of the exposures and the contribution that the Canning Dam rocks makes to our knowledge of the younger granite it is felt that some description of these rocks is warranted. Attention will be given only to the granitic rocks and consideration of the character of the later basic rocks will be deferred for a later paper, when it is hoped to deal with the quartz dolerites and epidiorites of the Darling Range.

The most informative exposures are to be seen in the east and south walls of the quarry and in various large boulders broken out during quarrying. Some of these are illustrated in Plate 1, figs. 1-2, which require very little explanation. Fig. 1 in Plate 1 is a view of a part of the east wall showing a large xenolith of the earlier dark coloured hybrid gneiss enclosed by the younger massive granite which also carries smaller xenoliths of the older material. It will be seen that the boundary between xenolith and host is extremely well defined by a narrow white (aplogranite) band and it may be noted that close examination of hand specimens from the boundary indicates that there is apparently no genetic relation between this material and the more acidic bands of the gneiss which appear to belong to an earlier period of granitisation. Both the older gneiss and the younger massive granite are intruded by aplite-pegmatite veins which, as will be seen from the petrological section of this paper, appear to represent an end phase of the younger granite magma. In addition there are, in the older gneiss, patches of darker rock which are remnants of a still earlier basic igneous rock which has been granitised and migmatised to form the older hybrid gneisses.

Figure 2 in Plate 1 is a view of a boulder showing the sharply defined border of the younger granite against the older gneiss—in this boulder the younger granite can be distinctly seen to transgress the more acidic bands of the gneiss. The banded character of the gneiss is evident, the darker coloured bands being thoroughly granitised pre-existing basic rock, the acid bands being more granitic and imparting a migmatitic structure to the rock.

From a study of the rocks in this quarry the age relations appear to be as follows:—

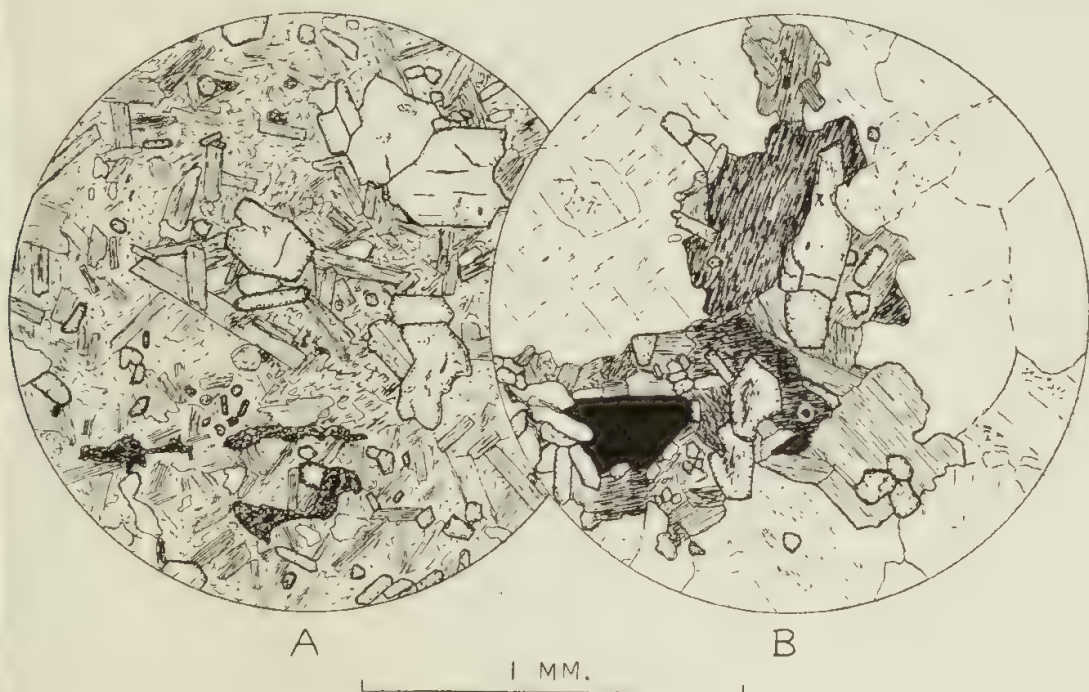
The oldest material is represented by the basic clots and patches in the gneiss, then follows the hybrid gneiss, then the younger granite, and, latest of all, the aplite-pegmatite dykes (it must be remembered that all of the above are intruded by the still later basic dykes which, however, are not being considered in this communication).



## PETROLOGY.

## (a) The Basic Xenoliths.

These are the fragments of dark greenish rock which are distributed irregularly through the hybrid gneisses. Amongst these rocks there is some variation of character but the most abundant type is an epidote-biotite rock of which specimen 20640\* is typical. It is a phaneric, fine, even-grained, almost black rock with no trace of any directed structure and, except for the presence of occasional larger grains of pyrite and very rare grains of plagioclase, appears to be of uniform character throughout. The micro-structure is decussate (text figure 1a), the rock consisting essentially of biotite and epidote with sporadic development of porphyroblastic plagioclase.



Text Figure 1.

- A. Basic xenolith (epidote-biotite rock) showing decussate arrangement of biotite, tablets of epidote, irregular areas of granular sphene (enclosing magnetite) and small xenoblastic grains of quartz and albite. The groundmass is of chloritic material.
- B. Younger granite showing the aggregate structure of the mafic constituents. The minerals of these basic clots are biotite, magnetite and epidote. The felsic minerals are microperthitic microcline at upper left, quartz at upper right and plagioclase at lower right corners of the field.

Accessories include quartz, rare apatite prisms and magnetite surrounded by granular sphene rims. The biotite is a greenish brown, practically uniaxial variety with X pale yellow brown, Y = Z greenish brown and  $\beta = 1.640$ . The basal faces are well developed but the terminations are ragged and the flakes (which are variable in size up to 0.75 mm. diameter) are arranged haphazardly. The interstices between the biotite flakes are filled with a pale greenish, practically isotropic chlorite towards which the biotite is idioblastic. The epidote is a pale yellowish-green pistachite in well shaped tablets up to

\* Numbers refer to the catalogue of the collection of the Geology Dept., University of Western Australia.



0.75 mm. long, uniformly distributed throughout, although in some places the prisms may be clustered together—the epidote is idioblastic towards all other minerals in the rock.

Porphyroblasts of albite up to 1.5 mm. diameter are distributed sporadically—they are always xenoblastic and enclose small grains of epidote and bright green chloritised biotite and appear to be of late introduction, probably representing the first stages of the granitisation of the rock.

The accessories are apatite and magnetite; the latter is associated with granular sphene which indicates its origin from original ilmenite.

The rock is very similar to the basic xenoliths noted by Thomson (1941, p. 271) in the gneisses at Cardup and to the basic xenoliths in the gneiss at Armadale (Prider, 1941, p. 34), although the latter contain considerable hornblende. It may be noted, however, that hornblende was present in small amount in some of the Canning Dam basic xenoliths.

An analysis of the biotite-epidote rock described above is set down in Column 2, Table 1, along with the analyses of basic xenoliths in the gneisses of nearby areas.

TABLE I.

*Analyses of Basic Xenoliths in the Darling Range Gneisses.*

	1.	2.	3.	
SiO <sub>2</sub> ...	40.09	41.42	44.95	
Al <sub>2</sub> O <sub>3</sub> ...	14.01	16.55	17.70	Norm of (2).
Fe <sub>2</sub> O <sub>3</sub> ...	6.05	2.21	3.12	
FeO ...	14.42	14.28	11.32	or ... 18.90
MgO ...	4.34	8.41	6.08	an ... 16.12
CaO ...	9.89	3.95	3.08	le ... 11.77
Na <sub>2</sub> O ...	0.46	2.36	3.03	ne ... 10.79
K <sub>2</sub> O ...	3.78	5.68	6.38	ol ... 31.32
H <sub>2</sub> O— ...	0.07	0.26	0.12	C ... 0.51
H <sub>2</sub> O+ ...	1.97	2.14	1.41	il ... 3.65
CO <sub>2</sub> ...	0.08	...	...	mg ... 3.25
TiO <sub>2</sub> ...	2.76	1.92	1.36	ap ... 1.34
BaO ...	Nil	Tr.	...	py ... 0.64
P <sub>2</sub> O <sub>5</sub> ...	1.24	0.53	0.95	
MnO ...	0.38	0.15	0.14	Classification—
FeS <sub>2</sub> ...	0.77	0.64	...	
Fe <sub>7</sub> S <sub>8</sub> ...	0.02	...	...	III. 7 . 2 . 3
V <sub>2</sub> O <sub>3</sub> ...	0.03	...	...	
	100.36	100.50	99.64	
Sp. Gr. ...	3.23	3.00	2.94	

1. Hornblende-epidote-biotite hornfels, xenolithic in hybrid gneiss, Armadale, Western Australia (Prider, 1941, p. 36).
2. Epidote-biotite rock (20640), xenolith in hybrid gneiss, Canning Dam Quarry, Canning Dam, Western Australia. *Anal.*—R. T. Prider.
3. Basic xenolith in gneiss, Cardup, Western Australia (Thomson, 1941, p. 271).

All of these analyses have the same unusual features of a low SiO<sub>2</sub> content associated with high potash and alumina. The Canning Dam and Cardup rocks (analyses 2 and 3) are of very similar chemical composition and differ from the Armadale rock (analysis 1) mainly in the MgO/CaO ratio. The unusual character of these basic xenoliths in the Darling Range gneisses may be shown by an endeavour to place them in the Quantitative Classification—the classification of the Canning Dam specimen (analysis 2)

is III.7.2.3 and the only other members of this classification are rare leucite basalts and tephrites. The general chemical features of these rocks (except for their high FeO/MgO ratio) are similar to the basic hybrid rocks of Ach'naire, Sutherlandshire, Scotland, which are considered by Read *et al* (1926, p. 154) to be hybrids between ultrabasic rocks and felspathic magma.

The three analyses quoted in Table 1 show serial characteristics for all the main oxides except MgO—with increasing SiO<sub>2</sub> there is a gradual increase in K<sub>2</sub>O, Al<sub>2</sub>O<sub>3</sub> and Na<sub>2</sub>O and a corresponding decrease in Fe<sub>2</sub>O<sub>3</sub> + FeO, CaO and TiO<sub>2</sub>. These constant variations are reflected in the specific gravities of the various rocks. The Armadale rock, in view of certain relict structures, was considered (Prider, 1941, p. 35-37) to have been originally a basic igneous rock which was altered by addition of potash from potash- and alumina-rich solutions from an intrusive granite (the hybrid gneiss). No such relict structures are present in the basic xenoliths at Canning Dam and Cardup which appear to be more completely metasomatised rocks of similar origin to the Armadale rock—this is supported by the higher potash, alumina and silica content of these rocks.

#### (b) The Hybrid Granite Gneisses.

These rocks are even-medium-grained with, in places, a well developed gneissic structure due to alternations of light and dark coloured bands which may be as much as several inches wide and may be somewhat lenticular in shape. Both the dark and light coloured bands are sharply truncated by the more coarsely crystalline younger granite. In other places the hybrid granite gneiss may be represented by a granitic gneiss with a very faint gneissic structure and occasional lenticular basic clots—this rock is distinguishable macroscopically from the younger granite by the faint gneissic structure due to a subparallel alignment of the biotite flakes and by its slightly finer grain.

The hybrid gneisses may be described as follows:—

(i) *The basic bands.*—These are fine- to medium-grained, dark in colour, containing abundant biotite in flakes of the order of 1 mm. diameter and occasional small irregular felsic areas. The constituents are biotite, hornblende, plagioclase, quartz, epidote, magnetite, sphene and apatite. The proportions of the main constituents vary from place to place, sometimes biotite (with associated epidote as in the basic xenoliths described above) is the sole ferromagnesian, sometimes it is accompanied by an approximately equal amount of a brownish green hornblende. In all instances the structure is granoblastic even-grained. The biotite, in the biotite-rich layers, occurs in clotted aggregates associated with epidote and rare magnetite grains recalling the structure of the basic xenoliths; some of these clotted aggregates are included in anhedral plagioclase grains. Plagioclase, however, more usually occurs in allotriomorphic granular mosaics with quartz and these mosaics occupy the spaces between the biotitic aggregates or between larger isolated biotite flakes. The plagioclase is clear to slightly dusty with kaolinic alteration products and appears to be constant in character (approximately Ab<sub>85</sub>An<sub>15</sub>) with very slight normal gradational zoning (the extinction of centre and periphery differing only by 2° or 3°). Quartz, the last mineral to crystallise, is always anhedral, varies in size up to 3 mm. diameter and all shows undulose extinction.



The structure of the hornblende bearing bands is even grained (average grain size 0.3 mm.) granoblastic with no tendency to a preferred orientation for any of the constituents. The minerals present are hornblende (20%), biotite (25%), oligoclase (40%), epidote (3%), magnetite (7%), sphene (3%), with minor amounts of quartz, apatite and zircon. The biotite is the brownish green type which occurs in the basic xenoliths and is idioblastic towards the hornblende which is a brownish green variety with  $X$  yellow green,  $Y$  brownish green,  $Z$  green (slightly bluish) and  $X < Y < Z$ . The plagioclase is always allotriomorphic, unaltered, and shows lamellar twinning in about half of the grains present. Quartz is always allotriomorphic and interstitial and is present only in small amount. Sphene is comparatively abundant, usually rimming magnetite euhedra; in some instances it is present in grains to 0.5 mm. diameter enclosing a number of separate magnetite grains: this magnetite-sphene association is clearly derived from original ilmenite.

(ii) *The acid bands.*—These bands appear to be normal granitic rocks with a slight gneissic structure. They are even-grained and under the microscope the subparallel alignment of the biotite flakes is visible and also a slight tendency to the elongation of quartz anhedral parallel to the gneissic banding. The constituents are oligoclase (50%), quartz (45%), biotite (5%), epidote (<1%) and very rare apatite. All constituents (except the rare epidote and apatite) are allotriomorphic. The biotite is the usual brownish green variety similar to that of the basic xenoliths and occurs as isolated flakes or in clotted aggregates (which may contain an occasional epidote grain and which are elongated parallel to the gneissic structure). The plagioclase is slightly turbid by alteration and is generally rather free from twinning. No zoning is visible and it is an oligoclase (approximately  $Ab_{55}An_{45}$ ). The quartz occurs in allotriomorphic grains which tend to be slightly elongated parallel to the gneissic structure. It all shows undulose extinction due to strain. There is a complete absence of microperthitic microcline, which is a characteristic constituent of the younger granite, and this affords one of the best means for distinguishing the two rock types.

The hybrid gneisses appear then to represent a series of basic and ultrabasic igneous rocks which have been metasomatised by alkalic solutions or vapours derived from a granitic magma (which has resulted mainly in the development of biotite from pre-existing ferromagnesian minerals) and migmatized by injection of granitic magma along foliation planes to give the more acid bands—this granitic magma itself being hybridised by the assimilation of some of the basic material. These two processes were effected simultaneously at an earlier period than the intrusion of the younger granite (as deduced from field relations and the different mineralogical composition of the hybrid granitic gneisses and the younger granite which is described below).

### (c) The Younger Granite.

The younger granite is a massive, even, medium-grained rock which is more leucocratic than the hybrid gneisses and lacks the banded structure. It carries small pegmatitic segregations and may be traversed by aplite-pegmatite veins which also traverse the xenoliths of hybrid gneiss enclosed by the younger granite—these pegmatites (which are described in a later section) appear to be end phase products of the younger granite magma.



The typical younger granite (e.g. spec. 20641) is massive, leucocratic, even-medium-grained (average grain size 1-2 mm.) with local pegmatitic segregations. A noticeable feature in hand specimen is that the mafic minerals occur in small aggregates (to 2 mm. diameter) distributed uniformly throughout the rock rather than as isolated biotite flakes. Under the microscope the texture is granitic, all the constituents being allotriomorphic. The minerals present are microcline, oligoclase, quartz and biotite, with accessory magnetite and epidote.

Biotite occurs in clotted aggregates associated with magnetite and epidote (text figure 1B). It is the greenish brown variety, similar in all respects to that of the basic xenoliths described above. The epidote is similar to that of the basic xenoliths both in regard to type and relations with the biotite. Magnetite, though comparatively rare, was found to form the greater part of several of these aggregates which were approximately 2 mm. diameter. These clotted aggregates resemble the basic xenoliths in the hybrid gneiss so closely that they must be regarded as micro-xenolithic bodies in the younger granite and indicate that this magma has also been hybridised to some extent.

Of the feldspars the plagioclase, although generally anhedral, may at times show subhedral form. It is invariably dusted with small granules of epidote and flakes of muscovite—these secondary products at times completely replace the plagioclase and are often recrystallised into epidote-muscovite aggregates. Lamellar twinning is occasionally present and the mineral, which appears to be constant in character, is an oligoclase close to  $Ab_{60}An_{40}$ . The oligoclase carries occasional rounded quartz inclusions of the order of 0.15 mm. diameter.

The microcline, which is generally microperthitic, is always anhedral and by contrast with the oligoclase is water-clear with no evidence of alteration—it shows a tendency to wrap around and at times completely enclose the more turbid oligoclase and is undoubtedly of later crystallisation. The pegmatitic segregations which occur sporadically in the younger granite consist in the main of this microperthitic microcline in anhedral Carlsbad twins up to one cm. in length with quartz and minor amounts of oligoclase (again subhedral and exhibiting the characteristic alteration as in the finer even-grained granite).

Quartz the only other mineral of importance in this rock is in anhedral grains to 1 mm. diameter, and all shows strain shadows under crossed nicols. The presence of rounded quartz inclusions in the oligoclase has been noted above.

The presence of micro-xenoliths of the epidote-biotite rock and of rounded quartz inclusions in the oligoclase indicates that the granite magma from which these rocks were derived was of syntectic origin, being either (a) developed by the fusion of the pre-existing granite-gneisses or (b) hybridised by partial assimilation of the pre-existing hybrid gneisses—the recrystallised epidote-muscovite aggregates after plagioclase probably represent an older plagioclase derived from the same source. The very uniform distribution of these older constituents throughout the rock indicates the thoroughness with which the admixture of pre-existing rock and granite magma has been effected and points to this hybridisation being effected at considerable depth followed by the intrusion of the hybridised magma into the earlier granitic gneisses.

A chemical analysis of the younger granite is given in Table II.

TABLE II.

*Analysis of Younger Granite (20641) from Canning Dam Quarry.*

SiO <sub>2</sub>	...	...	74.80				
Al <sub>2</sub> O <sub>3</sub>	...	...	13.93	Norm—			
Fe <sub>2</sub> O <sub>3</sub>	...	...	0.78	Q	...	...	34.86
FeO	...	...	0.97				
MgO	...	...	0.22	Or	...	...	19.46
CaO	...	...	1.92	Ab	...	...	33.01
Na <sub>2</sub> O	...	...	3.89	An	...	...	9.17
K <sub>2</sub> O	...	...	3.30				
H <sub>2</sub> O+	...	...	0.14	C	...	...	0.51
H <sub>2</sub> O—	...	...	0.24				
TiO <sub>2</sub>	...	...	0.14	hy	...	...	1.42
BaO	...	...	Nil				
P <sub>2</sub> O <sub>5</sub>	...	...	0.05	mg	...	...	1.16
MnO	...	...	0.02	il	...	...	0.30
			100.40	ap	...	...	0.17
Sp. Gr.	...	...	2.66	Classification—I	4	2	4

*Anal.*—R. T. Prider.

(d) The Pegmatites and Related Rocks.

As has been noted above there are two different types of pegmatite masses:—(i) Segregations in the younger granite and (ii) veins up to several feet wide intrusive into the younger granite and older hybrid gneisses. In addition there are narrow mineralised zones in the younger granite which appear to be genetically related to the pegmatite.

(i) The segregations vary in size up to several inches across and consist largely of micropertthitic microcline in Carlsbad twins up to 1 cm. long with quartz and minor amounts of oligoclase. There is a noticeable concentration of ferromagnesian minerals into a narrow zone several mm. wide around the edges of these segregations—in thin section this dark coloured material is seen to consist of brownish biotite associated with prismatic epidote, anhedral sphene with magnetite inclusions and euhedral magnetite (often with biotite flakes coating its surfaces). The structure of these patches is similar to that of the basic xenoliths, but a noticeable feature is the somewhat stronger absorption of the biotite in the pegmatite—in view of the structure and mineralogical composition these basic patches in the pegmatite segregations appear to be of the same origin as those in the granite.

(ii) The pegmatite veins are of two types—perthite bearing pegmatites and magnetite-pegmatites:—

The *perthite bearing pegmatite* which is the more abundant of these two types, is similar in all respects, except for a very much coarser grain, to the pegmatitic segregations in the younger granite and is undoubtedly related to the younger granite magma. It has a coarse pegmatitic texture, the constituents (up to 10 cm. diameter) being pale brownish grey perthitic microcline, milky white oligoclase, bluish white quartz, and black platy forms of the order of 5 cm. across, which at a distance appear to be large biotite flakes. Microscopic examination shows that these plates are fragments of an epidote-muscovite-biotite schist—the laminae of such “plates” consist of bands 0.3 mm. wide made up of a decussate aggregate of greenish brown biotite plates of the order of 0.08 mm. diameter peppered with minute



epidote granules, alternating with narrower biotite-muscovite bands with a similar decussate structure. These laminae have, in places, been prised apart by later crystallising microcline and oligoclase, clearly indicating the earlier origin of these fragments. The nature of the biotite and the decussate structure suggest that these platy fragments are remnants of a schistose type of basic xenolith (similar to those described above) which has been engulfed by the pegmatite.

The *magnetite-pegmatite* was noted in one place only in a large boulder broken out during quarrying operations. In this boulder the pegmatite traverses the banding of the hybrid gneiss and a noticeable feature is that the magnetite is confined to a zone approximately three inches wide at the edge of the dyke—unfortunately only one edge of the dyke is exposed so that no information can be gained as to whether or no this segregation is due to a gravitative separation of early formed magnetite. The magnetite, which forms at least 50% of the bulk of the edge zone of the dyke, is in closely spaced crystals up to 3 cm. diameter in a pegmatitic quartz-oligoclase groundmass. It has a well developed octahedral cleavage and is generally rimmed with a decussate aggregate of deep brown biotite which may also be developed along irregular cracks. At times these biotitic aggregates may completely replace the magnetite except for small irregular shaped relicts. Polished surfaces of the rock show that the biotitic rim is developed when the magnetite is in contact with oligoclase, but not when the contact is with quartz, indicating the origin of the biotite as a reaction product between the magnetite and oligoclase. The magnetite is also replaced in part by pyrite.

The central part of the magnetite-bearing pegmatite dyke is practically free from magnetite and is irregular in grain consisting mainly of medium grained granitic material with pegmatitic patches (in which fels-pars may be up to 5 cm. diameter) and streaks of aplite several inches wide, running parallel to the walls of the dyke. The granite portion of this rock is made up of an allotriomorphic granular mosaic of oligoclase and quartz with small mafic areas composed of biotite-epidote aggregates. The oligoclase is peppered with small muscovite flakes and epidote granules. Microcline is absent. The pegmatitic areas consist essentially of quartz and oligoclase and again microcline is absent. The aplite streaks on the other hand are rich in microperthitic microcline, consisting of an even grained granitic aggregate of microcline, oligoclase and quartz, and containing occasional small crystals of magnetite associated with epidote. Considering the dyke as a whole it appears that magnetite was the first mineral to crystallise, followed by the oligoclase granite (at which time the early formed magnetite suffered peripheral alteration to biotite) and then by the last phase rich in microcline (the aplites). In view of the presence of microperthitic microcline in the aplitic phase there can be little doubt that the magnetite pegmatites are genetically related to the younger granite magma, although they probably represent an earlier pegmatitic phase than the perthite-bearing pegmatites described above.

The magnetite pegmatites are very similar mineralogically, structurally, and in their associated rocks to the magnetite-pegmatites of Vermilion, Minnesota, U.S.A. (described by Grout, 1923) and those of Clinton Co., New York, U.S.A. (described by Miller, 1919 and 1921). Miller considers that the pegmatites of Clinton County, which are associated with granite-syenite intrusions into an older meta gabbro series, derived much of their iron from the older meta-gabbros. Grout on the other hand considers that, in the case



of the Vermilion pegmatites, the iron was first concentrated from a granite low in iron, into the pegmatites by the segregation of those pegmatites and then locally concentrated in some of the late pegmatites, rather than that it was derived by assimilation of the country rock. The magnetite pegmatites of Canning Dam are related to a granitic magma which has undoubtedly been considerably altered by assimilation of pre-existing basic rocks very rich in iron (14.28% FeO, 2.21%  $\text{Fe}_2\text{O}_3$ —see analysis 2 in Table 1) and although the magnetite is a primary mineral in the pegmatite it seems most likely that the original source of the iron was the older basic rocks that have left their imprint on all of the later intrusives (with the exception of the epidiorites which represent a still later phase of igneous activity than has been considered in this paper).

### SULPHIDE MINERALISATION OF THE GRANITES.

Two sulphide minerals have been noted in the Canning Dam granitic rocks, molybdenite and pyrite. The former was found in very small amount associated with small quartz segregations in the older hybrid gneiss. The latter occurs in a rock which can only be described as a pyrite granite, which occurs in veins several feet wide in the younger granite, and which is variable in texture from even medium-grained to coarse pegmatite. It is similar in all respects to the younger granite, consisting of microperthitic microcline, oligoclase and quartz, with the addition of up to 20% of pyrite which has the appearance of being a primary mineral of rather late crystallisation. The pyrite is coarse grained, comparable in size to the associated quartz and felspar grains and is anhedral, often being moulded around the felspar. Pegmatitic segregations in this granite (similar to those described under (i) above) also carry pyrite in grains 3 mm. diameter completely enclosed in large microcline crystals and as thin films along cleavage planes in the same crystal. In spite of the primary appearance of the pyrite it is difficult to think of it as being other than a replacement mineral and this suggestion of its origin is supported by the facts that the minerals of the associated granitic material all show signs of strain (undulose extinction of quartz grains and bending of the twin lamellae in the plagioclase) and that pyrite does occur as thin films along the cleavages of the last mineral to crystallise, viz., the microcline, in the pegmatitic segregations.

### SUMMARY AND CONCLUSIONS.

The complex nature of the Darling Range "granite" is only fully realised when freshly broken exposures in quarries are examined. At Canning Dam this granite complex consists (from older to younger) of:—

(a) Older basic rocks now represented by a variety of hornblende-biotite-epidote hornfelses which are considered to be derived from pre-existing basic igneous rocks. These occur in xenolithic patches in (b).

(b) Hybrid granite gneisses which have been formed by the thorough granitisation (both by metasomatism and migmatisation) of the older basic rocks.

(c) Younger microcline granite which has engulfed both (a) and (b) which now remain only in xenolithic form. It is considered that this granite intrusion belongs to a distinctly later period than the granite which gave rise to the hybrid granite gneisses. The younger granite magma was of syntectic origin being either highly hybridised by assimilation of pre-existing rocks or developed by fusion of the earlier granitic gneisses.

(d) End phases of the younger granite magma which have extensively replaced all of the abovementioned rocks. These end phases include aplites and pegmatites of various types, of which the magnetite pegmatites are considered to have derived their iron content from the oldest basic rocks.

(e) Sulphide replacements of narrow zones in the younger granite. Petrographical details regarding all the above members of the complex are given in the paper. All these rocks are traversed by still younger epidiorite dykes which have not been considered in this paper as they have produced no visible effects on the granitic rocks.

#### ACKNOWLEDGMENTS.

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## EXPLANATION OF PLATE I.

- Figure 1: View of wall at the south-east corner of the quarry showing a large xenolith of the hybrid granitic gneiss in the younger granite which occupies most of the left hand side of the photograph. Smaller xenoliths of the older gneiss in the younger granite are present in lower left corner. Note the contorted structure of the gneiss and the dark coloured remnants of the older epidote-biotite rock (the light coloured patches seen in the gneiss are defects in the photograph). Both the older gneiss and younger granite are traversed by a network of aplite-pegmatite dykes. The dimensions of the area shown in the photograph are 15 feet x 10 feet. *Photo by R. G. Royce.*
- Figure 2: Photograph of boulder showing younger granite (upper left) transgressing the foliation of the gneiss. Shows also the migmatitic structure of the gneiss. Dark area in lower left is shadow below the boulder. Clinometer rule (arms 6 inches long) gives the scale. *Photo by R. G. Royce.*





Fig. 1.



Fig. 2.



## 8.—ECOLOGICAL NOTES ON THE DE GREY-COONGAN AREA, WITH SPECIAL REFERENCE TO PHYSIOGRAPHY.

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Read 10th March, 1942.

### INTRODUCTION.

The area covered in this paper extends along the De Grey River from mouth to the junction with Bamboo Creek, i.e., a distance of about ninety miles, in the north and along the Port Hedland-Marble Bar Railway in the south. Most of the months May and June, 1941, were spent in this area and a large collection of the local flora was made.

The climate is semi-arid with very high summer temperatures. It is not unusual for the mercury to be over the century at its maximum for a week or so at a time. The rainfall which is predominantly summer in incidence, varies from about twelve to eight inches as one proceeds inland. The break in the dry weather is often marked by violent storms which cause great wind and flood damage. In other years the rains may fall over three or four months between December and March. There is a marked winter drought.

### PHYSIOGRAPHY.

To understand the variations in the vegetation it is essential to visualise the chief physiographic features of the region. As will be noticed on the map the De Grey River runs in a general W.N.W. direction across the area under discussion. Throughout its course it receives no tributaries from the north. On the southern side it is joined (moving from east to west) by Bamboo Creek, Soda Creek, Coongan River, Pier Creek, Shaw River and the Strelley River. Just west of the last junction the delta system is reached and the course divides into the De Grey and Ridley channels. The former branches again and then rejoins before reaching the sea.

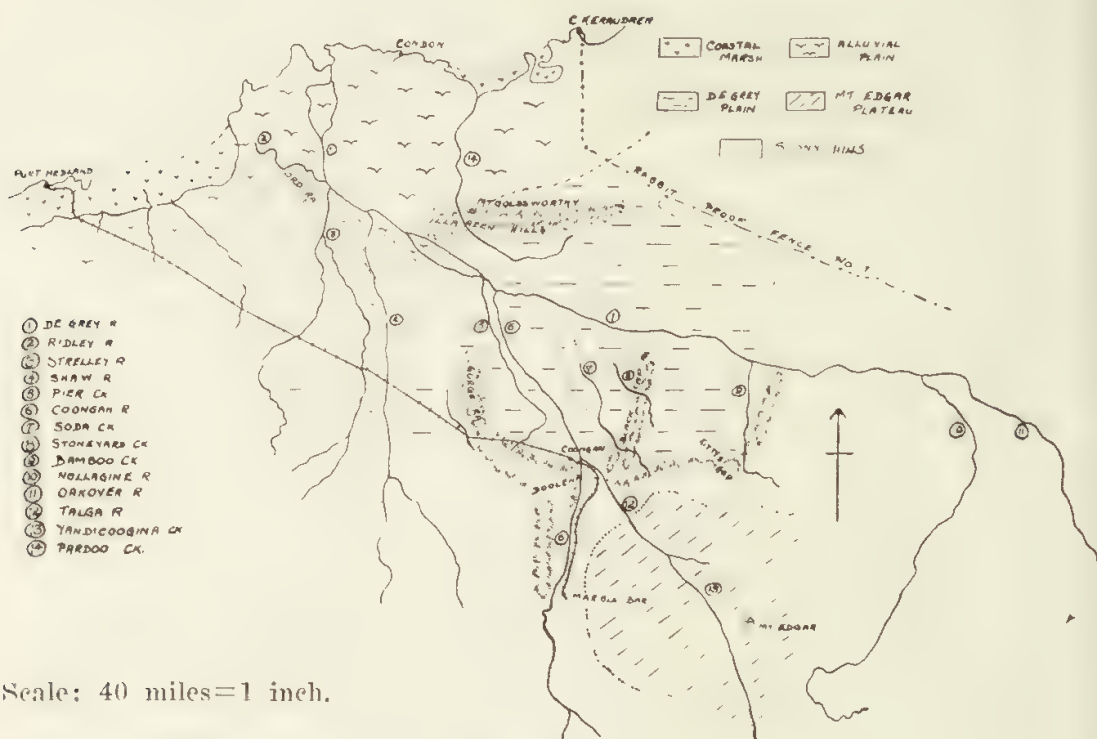
North of the De Grey is Pardoo Creek which during part of its course runs parallel to the river. Pardoo Creek has its own outlet to the sea.

Except for an alluvial plain along the coast (which includes the delta of the De Grey) the country between the railway and the river is a granitic plain. The general landscape is flat or gently undulating. In some places the plain is interrupted by ridges of low hills where there are outcrops of metamorphosed sediments. According to Gibb Maitland (1908) these rocks belong to the Warrawoona Series while the granite of the plain is a young formation. Of the hills the following may be listed:—Ord Range (or Muecingarra Hills) between Port Hedland and the De Grey, Illareen Hills (which include Mount Goldsworthy) to the north of the De Grey and traversed by the Pardoo Creek, Gorge Range between the Shaw and Coongan rivers and the Black Cap Hills which run north from Coongan Siding to the De Grey River and further. A gabbro dyke crosses the latter. There are various other ridges of hills without names. In all cases the hills rise very abruptly from the plain. In some places there are gaps in the ridges where creeks pass through. (See Plate II, Fig. 1.)



To the south of the granitic plain is a change of country where a low ridge of hills is reached. These are about the same height as those of the plain but there are series of ridges extending southwards to beyond Marble Bar. The hills are composed of metamorphosed sediments of Warrawoona and Nullagine age. It is in this rough hilly region that the rivers and creeks arise.

South-east from Marble Bar, where Mount Edgar Station lies, the country changes again into a rock strewn plateau which in this paper is referred to as the Mount Edgar Spinifex Plateau. Mount Edgar itself is a pyramidal hill, composed of rock of Warrawoona age, which dominates the granitic plateau. South of the plateau is more of the rough stony hill country.



Text Fig. 1.

The country can be divided into the following sections:—(i) Water courses. (ii) De Grey Spinifex plain. (iii) Stony Hills, and (iv) the Mount Edgar Spinifex Plateau.

(i) The river channels consist of sandy courses which may be as much as a mile wide in the flat country, viz., the Coongan River in some of its lower reaches. The coarse sand, which is light buff in colour, includes many large pebbles brought down from the stony hills. The wide channels are formed of a series of streams between which there are sand and pebble banks built up during flood periods. Permanent waterholes are to be found at various places along the rivers.

The fall of the plain towards sea level is very gradual and it might be expected that the river courses would meander. This is not so though the courses turn and twist a certain amount. The explanation is that in flood time when the whole channel is full the water is at top speed and its course is as straight as possible. When the floods recede the water occupies only the minor channels in the river bed.

The soil of the channels is more closely related to that of the stony hills than to that of the plain.

In the hills the creeks run in steep stony gullies. On the plateau they are more like those of the plain except that there is less sand and more rock material in the beds.

(ii) The De Grey Spinifex Plain extends from a few miles north of the river to the hills just south of the railway and from the alluvial plain on the coast to Bamboo Creek in the east. The soil is a red sandy loam varying to red sand. The colour is always darker and richer than that of the river sand.

(iii) The stony hills present a very arid appearance. The soil is scanty and lies between the numerous boulders on the treeless slopes.

South of Coongan siding the Coongan River is joined by the Talga River. Both these rivers have their gaps in the hills. The former passes through Doolena and the latter through Talga Gap. It is through the latter that the railway enters the hilly country. South of the gap the Talga course is to the east and this country has not been seen by the author. The railway and road follow a southward course parallel to the Coongan River.

(iv) In some features the Mount Edgar Plateau resembles the De Grey Plain. The soil is however lighter in colour and more sandy in nature. Out-crops of granite are very common. Mount Edgar itself is not granitic. The more important streams include the Talga River and Yandicoogina Creek with its tributaries.

### ECOLOGY.

No close study was made of the alluvial plain along the coast except adjacent to the De Grey River. The vegetation consists of a beach zone of mangrove swamps, a sand dune and salt marsh zone, which is influenced by some of the exceptionally high tides at some periods of the year, and then a transition zone into the spinifex plain.

The rest of the area can be treated under the main physiographic headings.

#### (i) Water Courses.

- (a) Rivers with woodland association.
- (b) Creeks without woodland association.
- (c) Stony gullies in the hills.
- (d) Small drainage courses.

(a) The vegetation along the rivers is dominated by the eucalypts, Blackbutt, River Gum (*Eucalyptus microtheca*), and Bloodwood (*E. dichromophloia*). The centre of the river course is a bare desolate scene of dry sand banks and piles of river gravel. On either side of this however, the eucalypts stand in a prolific growth of various species of grasses. These include *Eulalia fulva*, *Chrysopogon pallidus*, *Sorghum plumosum*, *Bothriochloa decipiens*, *Heteropogon contortus*, *Themeda australis*, *Iseilema premaea*, *Brachiaria Clementii*, *B. piligera*, *Panicum cymbiforme*, *Ichnanthus australiensis*, *Setaria Dielsii*, *S. Carnei*, *Xerochloa laniflora*, *Sporobolus actinocladius*, *S. pulchellus*, *Eriachne Bentharii*, *Eriachne aristidea*, *E.*

*glauca*, *E. obtusa*, *Diplachne parviflora*, *Eragrostis japonica*, *E. Basedowii*, *E. Dielsii*, *Leptochloa digitata*, *Neurachne Clementii* and other species. The introduced grasses *Cenchrus ciliaris* and *Cenchrus pennisetiformis* (Buffel Grasses) have assumed a dominant role along the lower stretches of the De Grey up to its junction with the Coongan River. Above this point and along the tributaries the native grasses retain their position. Non-Gramineous species include *Gomphrena Michelli*, *Tribulus terrestris*, *T. occidentalis*, *Polanisia icosandra*, *Indigofera trita*, *I. viscosa*, *Cucumis trigonus* and others but the grasses are dominant among the ground flora. (See Plate I, Fig. 1.)

Between the bare sand channels and the lateral grassy woodland, which varies greatly in depth, there is every possible gradation. Along the main course there are pools of varying size and importance from small pools to large permanent water holes. For a few months the pools are connected by shallow trickles of water. Around most pools and along any running water there is a zone dominated by small sedges. These include *Bulbostylis barbata*, *Cyperus bulbosus*, *C. aristatus*, *C. difformis*, *C. iria*, *C. ixiocarpus*, *C. Cunninghamii*, *C. vaginatus*, *Fimbristylis microcarpa*, *F. miliacea*, and *Eleocharis atropurpurea*. The sedges are associated with such species as *Eragrostis japonica*, *E. Basedowii* and *Calandrinia quadrivalvis*. *Chara* sp. is abundant in many pools and in running water.

On the high river banks outside the woodland, i.e., the main banks of the course, there is a zone of *Triodia angusta* N.T.B., ms. and *Triodia secunda* N.T.B., ms. which gradually merge into the *Triodia pungens* R. Br. of the spinifex plain.

Below the junction of the De Grey and Coongan the main river course is bordered by a flood plain which increases in width until it merges into the delta system below the Ridley junction. Along the flood plain the woodland association mingles with the *Triodia pungens* association while the latter retreats from the river until at the delta there are wide grass plains. Much of these grass plains has been overrun by the introduced Buffel Grasses but there is plenty of country still carrying native grasses. In some places there are patches of pure *Chrysopogon pallidus* covering many acres. The same can be said of *Eriachne Bentharii* which can be seen on the great mudflats where the silts carried down by the flood waters are deposited. The former grass is cut for hay. The latter is practically useless from a pastoral point of view.

The fine silts of the delta area overlies soil with water highly impregnated with mineral salts and so stock water is difficult to obtain. From reports it seems that the vegetation varies greatly from season to season according to the amount of flood water which reaches the area. Probably the soil becomes increasingly salt during a cycle of years without a flood. The flood, when it comes, deposits a new layer of silt and also, probably leaches some of the salt away. This type of country, which lies between the woodland association along the river and the sand dunes and mangrove swamps of the coast, carries a growth of *Sporobolus virginicus* a species which has two growth forms according to the condition of the soil. In salty country it forms erect culms 8-12 inches high in a dense mat while in better country it is a diffuse plant with long trailing culms up to twelve feet in length. In seasons of floods *Sporobolus* is associated with a vigorous development of *Trigonella suavissima*. This legume however takes a very obscure place during seasons without flooding.



(b) Creeks whose courses are not marked by development of the grassy woodland association are found both on the De Grey plain and on the Mount Edgar plateau. The banks of these creeks carry the same species of *Eucalyptus* and most of the grasses can be collected along the sand banks but there is no defined association and the grasses are mostly isolated plants. *Eriachne Bentharii* is one of the most abundant however, and it may extend along the creeks in a pure state for a hundred yards or so in some places. There is an increase in the number of shrubs present. These include *Acacia trachycarpa*, *Carissa lanceolata*, *Abutilon amplum* and *Cassia venusta*. The banks also carry many tussocks of *Triodia angusta* with an occasional one of *Triodia pungens*. Along the creek on the plateau there is a decrease in the number of trees and an increase in the number of species of *Acacia*. These include *Acacia pachycarpa*, *A. salicina*, *A. tumida* and *A. patens*. *Cassia oligophylla*, *Adriana tomentosa* and various smaller shrubs are also important.

(c) The steep gullies in the hills are drained by creeks whose beds contain piles of boulders. The water must drain very rapidly from such channels. The creeks are marked by an occasional Eucalypt and by other species such as *Ficus platypoda*, *F. orbicularis*, *Terminalia circumalata*, *Acacia trachycarpa* and smaller species such as *Corchorus parviflorus* var. *ovatus* and *Trichinium auriculifolium*.

The creeks as they emerge from the hills spread out into a number of distributaries. Sometimes there is no definite course left after a mile of the plain has been traversed.

(d) Under this heading the author has included all minor drainage courses on the plain and also claypans. The former are marked by a thicker line of trees and shrubs than is the surrounding plain. In the latter cases there are communities of species of *Spinifex* other than *Triodia pungens*. These are *Triodia angusta*, *Triodia secunda*, which are species near to *T. microstachya* R. Br., and *T. longiceps* J. M. Black. This last is particularly common on the Mount Edgar Plateau.

#### (ii) De Grey *Spinifex* Plain.

The plain has been defined under the physiographic section. On the northern side of the river the plain merges into the desert country where *Plectrachne Schinzii* replaces *Triodia pungens*. Pardoo Creek traverses some of the transition country. To the east of Bamboo Creek is unknown country to the author. The plain may be discussed under the following headings:—

- (a) *Triodia pungens* association.
- (b) *Plectrachne Schinzii* association.
- (c) Other species of *Triodia*.

(a) This is by far the most important association on the plain. It is found with or without associated trees such as *Eucalyptus dichromophloia*, *Dolichandrone heterophylla* and *Atalaya hemiglauca* and shrubs such as *Acacia pyrifolia*, *Carissa lanceolata* and species of *Abutilon*, *Sida*, *Corchorus*, *Cassia* and various legumes. (See Plate I, Fig. 2.)

The growth form of *Triodia pungens* is extremely variable. It may be (i) a pyramidal tussock up to three or four feet in diameter, of dense

habit and much resinous secretion on the leaf sheaths. This is a coarse form which is common on the plain. It is accompanied by a sparse development of trees and shrubs. (ii) a smaller tussock with very dark green leaves and very resinous leaf sheaths. It is the commonest form on the spinifex plain and is found in similar country to (i). (iii) A low flat tussock with dark green leaves. It may grow up to 6-7 feet in diameter and only a foot or so high. The older portions die away leaving a central dead patch. It has shorter leaves than the above types. It is usually found in country carrying a good growth of shrubs. (iv) A small dense tussock with yellowish leaves. This is an easy form to recognise in the field. It has a very wiry leaf whose blade is closed even when growing, though in the other forms the blade is open. It grows in open country with (i) and (ii). (v) A loose sprawling form with long trailing culms which have erect tufts rooted to the soil. This is the so-called Runner spinifex. It appears in country similar to that of (iii).

It may be stated here that there are no reliable taxonomic differences between these forms. The distinction is only possible in the field. These perennial tussock grasses dominate the landscape for many square miles. The association is a form of shrub steppe.

(b) The *Plectrachne Schinzii* association is locally referred to as pindan. This native word has been used rather generally in the North-West. However, for scientific purposes, it was defined by Gardner (1923) as a form of low sclerophyllous woodland in which the average height of the trees is 25 feet. He expressly states that it is not a grassland development. Further south than the Kimberleys, where Gardner studied this type of association, the word is applied to spinifex country which carries a large number of shrubs of certain species, particularly species of *Acacia*. The trees are all small and under 25 feet high. The author has decided to define this country as "spinifex pindan," i.e., sandy country carrying either *Plectrachne Schinzii*, or a species of *Triodia* in association with shrubs and trees up to twenty feet high. The trees often occur in thickets.

Spinifex pindan owing to the lower fodder value of the grass species and to the more arid habitat is sometimes referred to as desert country. Along the 80-Mile Beach the distinction can be made between *Triodia pungens* pindan and *Plectrachne Schinzii* pindan. In the De Grey country this division cannot be made. Here spinifex pindan occurs as patches in the general *Triodia pungens* association of the plain.

The shrubs and trees include *Atalaya hemiglauca*, *Dolichandrone heterophylla*, *Grevillea agrifolia*, *Acacia tumida*, *Acacia holosericea*, *A. pachycarpa* and *A. pyrifolia* as well as mallee forms of *Eucalyptus dichromophloia* and *E. setosa*. The smaller shrubs include *Cassia oligophylla*, *C. desolata*, *Indigofera monophylla*, *Isotropis atropurpurea*, *Acacia translucens*, *Keraudrenia integrifolia*, *Corchorus Walcottii* and *Melaleuca lasiandra*.

(c) *Triodia lanigera* was found forming colonies within the *Plectrachne* association. It appeared to favour habitats where the pindan sand was mixed with numerous quartz pebbles.

Other species of *Triodia* include those dealt with under subsection (d) of the previous section. These species sometimes occur as small colonies on the open plain.



(iii) *The Stony Hills.*

The stony hills carry a modified form of the *Triodia pungens* association of the plain. The trees and shrubs almost disappear except in the gullies. The vegetation along the creeks has already been discussed.

The form of *Triodia pungens* is a small tussock with very short culms and long leaves. *Triodia brizioides* N.T.B., ms., is a glaucous species with slender very pungent pointed leaves. It occurs on some slopes. (See Plate I, Fig. 2.)

When the spinifex cover is destroyed by fire there is a vigorous growth of *Polanisia icosandra*, *Tribulus hirsutus*, *T. Forrestiana*, *Didiscus hemiarpa* and *Trichinium auriculifolium*.

Among the shrubs are *Indigofera monophylla*, *Solanum diversifolium*, *Solanum phlomoides*, *Trichinium incanum*, *Triumfetta appendiculata* and various species of *Corchorus*. The trees include very occasional specimens of *Eucalyptus* and *Ficus platypoda*.

(iv) *The Mount Edgar Spinifex Plateau.*

The Mount Edgar Spinifex Plateau, except along the creeks, is lacking in eucalypts. The only mesophanerophytes are *Acacia pyrifolia* which only just attains this class, *Hakea lorea* and *Grevillea pyramidalis*. The ground cover is composed of *Triodia pungens* with a similar tussock to that described under (ii) in the De Grey Spinifex Plain. Where this cover is removed by fire there is a growth of annuals which include *Polanisia icosandra*, *Mollugo molluginis* and *Tribulus hirsutus*. Malvaceous and Tiliaceous shrubs are abundant.

The plateau is rock strewn and there are piles of granite boulders everywhere. Near such outcrops *Triodia longiceps* is common. This is a coarse glaucous species with leaf blades rigid, pungent and up to twelve or sixteen inches long. The tussocks may be up to five feet in diameter and four in height. The tall shrub *Clerodendron floribundum* was found growing among the boulders. Various species of *Tephrosia* particularly *T. Bidwilli* were very common.

The pindan association was not seen in this locality. Its absence together with the general lack of eucalypts, the small number of growth forms of *Triodia pungens* and the edaphic differences serves to distinguish the area from the De Grey Spinifex Plain.

Below the different habitats are analysed using Raunkiaers method:—

Area.	No. of Species.	M.M.	M.	N.	Ch.	H.	G.	HH.	Th.	E.	S.
De Grey-Coongan	334	0.8	7.2	15	6.5	9	....	1.5	58	...	....
Water Courses ....	195	1.5	3	5	2	11	....	2	73	....	....
Spinifex Plain ...	150	...	10	18	6	10	...	...	53	...	....
Stony Hills ...	93	....	3	30	18	15	...	....	38	...	....
Mt. Edgar Plateau	121	...	13	21	15	13	...	...	36	...	...



## SUMMARY.

The area bordered by the coast in the west, the courses of the De Grey River and Pardoo Creek in the North, Bamboo Creek and Mount Edgar in the east and by the Marble Bar-Port Hedland railway in the south is discussed under the headings of physiography and ecology. These two aspects are closely related.

The whole area is within the ecological region where *Triodia pungens* is the dominant form.

The following divisions are recognised:—(i) Water Courses with and without grassy woodland association, (ii) De Grey Spinifex Plain, (iii) Stony Hills, (iv) Mount Edgar Spinifex Plateau.

## REFERENCES.

- Gibb Maitland: The Geological Features and Mineral Resources of the Pilbara Goldfield. *Geol. Surv. West. Aust. Bull.* 40, 1908.  
Gardner, C. A.: Botanical Notes on the Kimberley Division of Western Australia. *Forests Dept. Bull.* 32, 1923

## EXPLANATION OF PLATES.

## PLATE I.

Fig. 1.—River Woodland Association, *Leptochloa digitata* in the foreground. Muccan Station, De Grey River.

Fig. 2.—De Grey Spinifex Plain. *Triodia pungens* associated with *Hakea lorea*, *Carissa lanceolata* and *Acacia pyrifolia*. Warralong Station.



Fig. 1.



Fig. 2.

## PLATE II.

Fig. 1.—Stoneyard Creek Gap in the Black Cap Hills. Hills rise abruptly from the De Grey Spinifex Plain, which is treeless in this locality. Muccan Station.

Fig. 2.—Kitty's Gap, showing typical stony hill vegetation.





Fig. 1.



Fig. 2.



## 9.—AUSTRALITE OBSERVED TO FALL AT COTTESLOE—A CORRECTION.

BY H. BOWLEY, F.A.C.I.

Read 8th June, 1943.

In the Royal Society Journal, Vol. XXV., 1938-39, the late Dr. E. S. Simpson described an Australite which a Mr. F. Hanson stated he had seen to fall in Kathleen Street, North Cottesloe.

Following an enquiry from the Society of Research for Meteorites in America I wrote to Mr. Hanson asking for the time and date when he saw this Australite fall. A Mr. Hammer, a relation of the Hanson family, came in to the Laboratory in answer to this letter. He stated that the Australite shown to Dr. Simpson, and now in the Western Australian Museum, is one that he found in a ballast pit on the railway between Narrogin and Merredin in 1925, and not the one stated to have been seen to fall by Hanson in 1935. This Australite was found about three feet six inches below the surface while working the ballast pit; the Australite was covered in clay and had evidently been there a long time. The men working on the railway chipped the Australite by placing it on the rail near where it was found and trying to break it with a hammer, or pick. Hammer gave this Australite to the Hanson family.

The object seen to fall by Hanson is now lost; it was stated by Hammer that it was irregular in shape and about the size of a hand. Hanson told Hammer that it made a small pit in the tennis court where it fell; there was a flash of light and a smell, and the object was warm when dug up.

Subsequently Mr. J. C. Hood, through whose friendship with Mr. A. N. Carter, Hanson's employer, the Australite had first been brought to Dr. Simpson's notice, saw Mr. Carter who questioned Hanson very carefully again. Hanson admitted that the Australite given to Dr. Simpson and stated to be the one seen to fall, actually was the Australite given to the Hanson family by Hammer many years before. Hanson stated that he did not know that there were two Australites in his house at the time he was asked to bring in his find to show Dr. Simpson.

Until the object seen to fall at Cottesloe can be found, it is not known whether it is an Australite or not. The Australite at the W.A. Museum did not come from Cottesloe but from a spot between Narrogin and Merredin, the exact locality of which has not yet been ascertained.





# THE ROYAL SOCIETY OF WESTERN AUSTRALIA. Inc.

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1942 - 1943



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# The Royal Society of Western Australia (Inc.).

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR ENDING  
30th JUNE, 1943.

*Ladies and Gentlemen,*

Your Council begs to submit the following report for the year ended 30th June, 1943.

*Council.*—As in the past several years an Executive Committee was appointed to deal with the routine business of the Society, and to report quarterly to the Council. The Council met on five occasions and the Executive Committee on five occasions during the year.

*Finance.*—The General Fund shows a balance of £225 3s. and the Endowment Fund now amounts to £299 0s. 6d. There are certain commitments to the Government Printer against the General Fund in connection with the publication of Volumes 27, 28 and 29, the last two of which have not yet been completed.

*Membership.*—Our membership remains almost the same as at the commencement of the year. Members elected during the year include one life member, nine ordinary members, and three student members. Two associates have transferred to full membership, and one full member to associate membership. Four ordinary members and one associate have resigned during the year. There are at present 154 members of the Society, made up as follows:

Honorary members	..	..	..	..	7
Corresponding members	..	..	..	..	9
Life members	..	..	..	..	2
Associate members	..	..	..	..	32
Ordinary members	..	..	..	..	101
Student members	..	..	..	..	3

*Journal.*—Volume 27 is now complete and it is hoped that 28 and 29 will be completed during the coming year. During the past year nine papers were presented to the Society for publication in the Journal. The delay in publishing has been unfortunate but unavoidable, due to wartime difficulties.

*Library.*—The Society has now entered into exchange of publications with a total of 189 institutions, of which 56 are in Australia, 16 in the United Kingdom, 23 in other parts of the British Empire, 48 in North and South America, 42 in Europe, and four in Asia. Some exchange publications are coming to hand more or less regularly, but in many instances overseas institutions are holding their publications in reserve to be forwarded after the war. The Council of the Society has decided, in view of the danger of loss during transit, to hold copies of its Journal which would normally be sent overseas, and to forward them on the cessation of hostilities.

R. C. WILSON,

President.

C. F. H. JENKINS,

A. G. NICHOLLS,

Joint Honorary Secretaries.



## THE ROYAL SOCIETY OF WESTERN AUSTRALIA, INCORPORATED.

*Statement of Receipts and Expenditure for the Year ended 30th June, 1943.*

Receipts.				Expenditure.			
General Fund—				General Fund—			
Balance at 1st July, 1942	£	s.	d.	Petty Expenses, Postage, etc.	£	s.	d.
Interest on Current Account to 1st June, 1943				Clerical Assistance	146	1	5
Subscriptions:				Rent Institution of Engineers	3	7	6
Annual Current and Arrears	113	12	7	Meetings, Catering and Protector Hire			
In Advance	6	6	0	Government Printer			
Life Membership	21	0	0	Vol. XXVII., Nos. 13-19	95	4	11
Transfer from Life Membership	1	6	2	Other Expenses	0	13	9
Government Grant				Miscellaneous Printing	142	4	9
Authors' Reprints, Blocks, etc.				Subscription—Australian Journal of Science	100	0	0
				War Damage Insurance	31	12	5
				Transfer to Medal Fund			
				Transfer to Life Membership Fund			
				Miscellaneous Expenses			
				Balance at 30th June, 1943			
					£423	6	1
Medal Fund—				Medal Fund—			
Balance at 1st July, 1942	£	s.	d.	Cash at Bank, Account S361, 30th June, 1943	£	s.	d.
Transfer from General Fund	4	3	0		9	5	5
Interest	5	0	0				
	0	2	5				
	£9	5	5				
Life Membership Fund				Life Membership Fund			
Balance at 1st July, 1942	£	s.	d.	Transfer to Endowment Fund, Account S417	£	s.	d.
Life Membership Subscription	18	0	0	Transfer to General Fund	38	0	0
Interest	21	0	0		1	6	2
	0	6	2				
	£39	6	2				
Endowment Fund				Endowment Fund			
Balance at 1st July, 1942:	£	s.	d.	Balance at 30th June, 1943	£39	6	2
250 War Savings Certificates at Valuation	212	10	0	250 War Savings Certificates at Valuation			
1956 War Loan	40	0	0	1956 War Loan	218	15	0
Cash at Bank	0	19	3	Cash at Commonwealth Savings Bank, Account S417	40	0	0
Interest:				Life Membership Fund held in Savings Bank Account S417	2	5	6
Estimated Interest on War Savings Certificates	6	5	0		38	0	0
Interest on 1956 War Loan and Account S417	1	6	3				
Held on account of Life Membership Fund							
	7	11	3				
	£38	0	0				
	£209	0	6				



## ABSTRACT OF PROCEEDINGS, 1942-1943.

## 14TH JULY, 1942—

Annual General Meeting in Gladden Hall. Presidential Address: "Outlines of the Plant Geography of Western Australia," by Mr. C. A. Gardner.

## 11TH AUGUST, 1942—

*Paper*.—"Marine Copepoda from Western Australia (Part III.)—Littoral Harpacticoids from Port Denison," by Dr. A. G. Nicholls.

*Address*.—"The History of the Discovery of Western Australian Marsupials," by Mr. L. Glauert, B.A.

*Election of Member*.—Miss D. F. Sandars, B.Sc., as an Ordinary Member.

*Exhibits*.—H. STEEDMAN—Specimens of local wildflowers.

## 8TH SEPTEMBER, 1942

*Address*.—"Anthropology," by Mr. F. R. Mitchell, President of the Royal Anthropological Society of Australasia.

*Exhibits*.—

L. GLAUERT—Specimens of petrels, normally rare, but of which numerous specimens had been collected during the winter.

E. M. WATSON—Specimens of plastic materials, their composition, special properties and chief uses.

H. P. ROWLEDGE—Specimens of ore containing a high proportion of titanium oxide.

K. R. MILES—Specimens of limestone collected in the pre-Cambrian rocks of the Mt. Margaret Goldfield.

H. STEEDMAN—Specimens of some less common wildflowers.

## 13TH OCTOBER, 1942—

*Paper*.—"Marine Copepoda from Western Australia (Part IV.)—Psammophilous Harpacticoids," by Dr. A. G. Nicholls.

*Address*.—"Some Adventures in the Art of Vinegar Making," by Dr. G. L. Sutton.

*Exhibits*.—H. STEEDMAN—Specimens of a number of wildflowers.

## 10TH NOVEMBER, 1942—

*Papers*.—"West Australian Freshwater Calanoids (Copepoda): (I.) Three new species of *Boeckella*, with an account of the developmental stages of *B. opaqua* n.sp., and a key to the genus; (II.) Two new species of *Brunella*, with an account of the developmental stages of *B. subattenuata* n. sp.," by Mr. W. S. Fairbridge, B.Sc.

*Address*.—"The Sheep Blowfly Problem," by Mr. C. F. H. Jenkins, M.A.

*Election of Member*.—Mr. H. V. V. Noone, as an Ordinary Member.

*Exhibits*.—H. STEEDMAN—Specimens of some less common wildflowers including the black Kennedyia.

## 8TH DECEMBER, 1942

*Papers*.—

"Five new Microcotylids from Fish from Western Australian Waters," by Miss D. F. Sandars, B.Sc. (Hon.).

"Marine Copepoda from Western Australia (V.). A new species of *Paramesochra*, with an account of a new Harpacticoid Family, the Remaneidae, and its affinities," by Dr. A. G. Nicholls.

*Election of Member*.—Pilot Officer J. H. Lord, as an Ordinary Member.

*Exhibits*.

C. F. H. JENKINS—The Argentine Ant and its Distribution and Control.

C. TEICHERT—Specimens illustrating the existence of ancient shore lines.

MISS A. M. BAIRD—Photographic illustration of the effect of fire in King's Park on the growth of spear grass, veldt grass, and *Acacia puechella*.

J. SHEARER—Photographs of X-ray diffraction patterns of powdered substances.

E. M. WATSON—Demonstration of a self-stirring cell for the electro-deposition of metals.

H. STEEDMAN—Specimens of wild flowers.



TH MARCH, 1943—

*Paper*.—"Granitic Rocks from the Canning Dam," by Dr. R. T. Prider.

*Address*.—"The Flax Industry in Western Australia," by Mr. H. G. Elliott.

*Election of Members*.—Miss V. Sims and Mr. J. M. Thomson, as Ordinary Members.

*Exhibits*.—H. STEEDMAN—Specimens of a larval mantis in the process of hatching from the eggs.

3TH APRIL, 1943—

*Address*.—"Butter Manufacture," by Mr. M. Cullity, B.Sc. (Agric.).

*Election of Member*.—Mr. E. E. T. Layton, as an Ordinary Member.

*Exhibits*.—

L. GLAUERT—Specimen of the frog *Metacrinia nichollsi* which is associated with the bull ant in the South West.

H. STEEDMAN—Several species of *Banksia*.

K. R. MILES—Demonstrated the use of an ultraviolet prospecting lamp used particularly for the detection of Scheelite.

1TH MAY, 1943—

*Address*.—"Swine Fever," by Dr. H. W. Bennetts.

*Exhibits*.—C. F. H. JENKINS—Specimens of two recently introduced insect pests, *Typhlocyba australis* and *Pieris rapae*.

TH JUNE, 1943—

*Paper*.—"Australite Observed to fall at Cottlesloe—A correction," by Mr. H. Bowley, F.A.C.I.

*Address*.—"Notes on the Houtman Abrolhos Islands from the Scientific Aspect," by Mr. A. Gibb Maitland.

*Election of Members*.—Mr. G. P. Whitley, as a Life Member; Miss M. E. Allen, Mrs. M. A. Nicholls, and Miss P. M. Sambell, as Ordinary Members.

*Exhibits*.—

MISS A. M. BAIRD—Collection of Marine algae from the Abrolhos Islands collected by the Percy Sladen Trust Expedition.

H. STEEDMAN—A number of botanical specimens.

## THE ROYAL SOCIETY OF WESTERN AUSTRALIA (INC.)

### KELVIN MEDALLIST, 1941.

The Royal Society's Kelvin Medal, instituted in 1924, to be awarded at four-yearly intervals for distinguished work in science in Western Australia, was, in 1941 awarded to E. de C. Clarke, Professor of Geology in the University of Western Australia. The presentation of the medal was made by His Excellency the Lieutenant-Governor of Western Australia, Sir James Mitchell, K.C.M.G., Vice-Patron of the Society, at the Annual General Meeting on 8th July, 1941.

Edward de Courcy Clarke, born at Waimate North, New Zealand, on the 10th November, 1880, was educated at the High School, Napier, N.Z., and at University College, Auckland, N.Z. On the completion of his university studies in 1901 he was appointed Science Master at Auckland Grammar School, N.Z., a position which he occupied till 1905. During this time his main interest was in palaeontology and he did post-graduate work in botany, obtaining First Class Honours in this subject. In 1905 he joined the staff of the Geological Survey of New Zealand as a Field Geologist. He held this position until 1910 and conducted a number of extensive and important surveys in the Nelson, Hokianga and Taranaki Divisions.

In 1910 Professor Clarke relinquished his position as Field Geologist to return once more to academic work as Demonstrator in Geology and Biology at University College, Auckland, but in 1912, receiving an appointment as Field Geologist with the Geological Survey of Western Australia, he again turned to field work. He was associated with the Geological Survey of Western Australia from 1912 till 1920, during which period he undertook a number of important surveys, the results of which were published in the Bulletins of the Geological Survey. Outstanding examples of his work include Bulletins describing the geology and mineral resources of portions of the Murchison, Yalgoo, East Coolgardie and North-East Coolgardie Goldfields, and, in conjunction with Mr. H. W. B. Talbot, a Bulletin containing the results of an extensive reconnaissance survey of the country between Laverton and the South Australian border.

In 1920 Professor Clarke was appointed Lecturer-in-Charge of the Department of Geology at the University of Western Australia, where he has remained till the present, being given the title of Associate-Professor in 1928 and Professor of Geology in 1930. During this time Professor Clarke's main interest has been in the Pre-Cambrian formations which form so much of the southern half of the State and this interest is evidenced by his Presidential Addresses to the Royal Society in 1923 and to the Geological Section of the Australian and New Zealand Association for the Advancement of Science in 1930. In addition he has done much original work on physiographic problems, chiefly in the South-West, but also on the broader aspects of physiography in Western Australia. During his association with the University of Western Australia, Professor Clarke has not only found time for much research, but has also been the source of inspiration of the work of many others. Above all he has insisted that training in actual field survey methods and not simply inspectional field work, is an indispensable requisite in the training of geologists. The value of this type



E. de C. CLARKE, Kelvin Medallist, 1941

of training is seen in the high respect that his past students enjoy in many parts of Australia and it must be a matter of considerable satisfaction to him that the Western Australian Geological Survey, of which he was a member for some years, is now almost entirely staffed by his graduates.

He has rendered much valuable service to this Society, having at various times occupied the offices of Hon. Secretary and Hon. Editor, and he has



twice been President of the Society (in 1922-3 and 1935-6). In addition he was President of the Geological Section of the Australian and New Zealand Association for the Advancement of Science at the Sydney Meeting in 1930. He is a Fellow of the Geological Society of America and of the A.N.Z.A.A.Sc. and a member of the Australian National Research Council (for many years its local secretary in W.A.). In addition he has been for many years an active member of the Western Australian Committee of the Council for Scientific and Industrial Research.

The high quality and originality of his work and the inspiration he has yielded to geological research in Western Australia are now recognised in this award of the Kelvin Medal, the highest honour that can be bestowed by this Society of which he has been for so long an enthusiastic supporter.

A list of publications for which Professor Clarke has been partly or wholly responsible is as follows:—

1904. "The Fossils of the Waitemata and Papakura Series." *Trans. Inst.*, Vol. XXVII.
1907. "The Geology of the Parapara Subdivision" (with J. M. Bell and E. J. Webb). *N.Z. Geol. Surv. Bull.* No. 3.
1909. "The Geology of the Whangaroa Subdivision" (with J. M. Bell), *N.Z. Geol. Surv.* No. 8.  
"Geological Reconnaissance of Northernmost New Zealand" (with J. M. Bell). *Trans. Inst.*, Vol. XLII.
1911. "The Geology of the Dun Mountain Subdivision" (with J. M. Bell and P. Marshall). *N.Z. Geol. Surv. Bull.* No. 12.  
"The Geology of the New Plymouth Subdivision." *N.Z. Geol. Surv. Bull.* No. 14.
1914. "Notes on the Geology and Mining at Sandstone and Hancock." *Geol. Surv., W.A., Bull.* No. 62.
1916. "Geology and Ore Deposits of Meekatharra." *Geol. Surv., W.A., Bull.* No. 68.
1917. "A Geological Reconnaissance of the Country between Laverton and the South Australian Border" (with H. W. B. Talbot). *Geol. Surv. W.A., Bull.* No. 75.
1918. "Geological Results of an Expedition to the South Australian Border" (with H. W. B. Talbot). *Journ. Roy. Soc., W.A.*, Vol. 3.
1920. "Boulders, possibly glaciated, near Leonora and Laverton." *Journ. Roy. Soc., W.A.*, Vol. VI., Part II.
1923. "The Pre-Cambrian System in Western Australia." *Journ. Roy. Soc., W.A.*, Vol. IX., Part II.
1925. "Leonora-Duketon District." *Geol. Surv., W.A., Bull.* No. 84.  
"Rothsday and Payne's Find." *Geol. Surv., W.A., Bull.* No. 86.  
"Monger and St. Ives." *Geol. Surv., W.A., Bull.* No. 90.
1926. "The Geology and Physiography of the Neighbourhood of Perth, W.A." in *Science in Western Australia* (a handbook for the 18th Meeting Aust. & N.Z. Ass. Adv. Sci.).
1927. "Natural Regions in Western Australia." *Journ. Roy. Soc., W.A.*, Vol. XII.  
"The Geology and Physiography of Parts of the Darling Range" (with F. A. Williams). *Journ. Roy. Soc., W.A.*, Vol. XII.
1931. "The Pre-Cambrian Succession in some parts of Western Australia." *Rep. Aust. and N.Z. Ass. Adv. Sci.*, Vol. XX.
1936. "Water Supply in the Kalgoorlie and Wheat Belt Regions of W.A." *Journ. Roy. Soc., W.A.*, Vol. XXII.
1938. "Middle and West Australia." *Regionale Geol. der Erde*, Band I, Abs. VII.
1939. "Metasomatism near Ore-Bodies" (with H. A. Ellis). *Economic Geology*, Vol. XXXIV, No. 7.

## PRESIDENTIAL ADDRESS, 1943.

A Presidential Address entitled "**The Collie Coalfield, its Problems and its Economic Importance**" was given by the retiring President, Mr. R. C. Wilson, B.Sc., B.E., Syd., M.Inst.M.M., London. Unfortunately circumstances have prevented its publication in this Journal. By arrangement, however, it is being published as an Appendix to the Annual Report of the Mines Department for the year 1944.

The subject matter of the address, which was accompanied by a number of plans, cross-sections and photographs, is outlined by the author in the following summary.

"The existing knowledge on the coalfield is reviewed.

The geology of the area under consideration is dealt with in a general way and particularly insofar as it concerns the amount of available coal or has any bearing upon exploratory work and underground mining operations.

An instructive model of the coalfield was exhibited. This model was prepared under the author's supervision by Mr. I. R. Berry, Chief Draftsman of the Mines Department, and his assistants. This model permits the numerous coal seams which exist to be more readily traced throughout the field than was previously possible.\*

An estimate of coal reserves is submitted based on our present information of the field. It is estimated that in the portion of the field which has been prospected to some extent there are fifteen coal seams averaging 5 feet or more in thickness containing 1,521 million tons of coal. In addition there is an area containing coal, but our knowledge of it is insufficient to admit of any estimate of the amount of coal it contains.

Great importance is attached to a knowledge of the many faults which occur. Some of the principal ones are described and these are also clearly shown on the model.

Attention is drawn to our incomplete information concerning a large proportion of the coalfield and also, in the absence of sufficiently deep boreholes, to our lack of knowledge of the behaviour of the coal seams at depth.

Reference is made to the occurrence of artesian water and to the amount of underground water generally.

The method of mining is briefly described as are also the principal creeps which have resulted from the adoption of this method.

Some suggestions are put forward regarding much needed increased production.

The nature of the coal is discussed at some length.

Mention is made of the increased demand for Collie coal as the result of the increased activities of the Railways and the Power Station combined with the development of secondary industries.

Attention is drawn to the wisdom of the State policy of utilising Collie coal whenever possible, thus giving the State an independence which is most valuable during the present war period, when the shipping position has rendered the importation of large quantities of New South Wales coal impracticable."

\* This model will remain at the Mines Department, Perth, and can be inspected by arrangement with the Under Secretary for Mines.

THE DATES OF PUBLICATION OF THE JOURNAL OF THE WEST AUSTRALIAN NATURAL HISTORY SOCIETY, THE JOURNAL OF THE NATURAL HISTORY AND SCIENCE SOCIETY OF WESTERN AUSTRALIA AND THE JOURNAL OF THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

By E. M. WATSON.

Information concerning the dates of publication of early parts and volumes of this Society's Journal and those of its predecessors is of considerable importance in determining priority of publication of papers dealing with taxonomic subjects.

This investigation was undertaken at the request of the Council of the Society and the information published in this paper has been obtained through the examination of the minutes of council and general meetings of the societies, from minutes and reports of publication committees, from financial statements and from accounts from the societies' printers. A full statement of the evidence of publication is appended to the minutes of the meeting of the executive of the Society held on 17th November, 1944.

For the sake of completeness, the publishing dates of the publications of the Mueller Botanic Society of Western Australia are appended.

*Journal of the West Australian Natural History Society.*

Year.	Number.	Date of Publication.
1904	I. ....	May, 1904.
1905	II. ....	May, 1905.
1906	III. ....	Between 18th September and 16th October, 1906.
1907	IV. ....	November, 1907.
1908	V. ....	Between 18th August and 20th October, 1908.
1909	VI. ....	February, 1909.

The name of the Society was changed at a general meeting held on 17th August, 1909, to "The Natural History and Science Society of Western Australia" and subsequent volumes of the Journal were published under this name. The first issue was numbered Volume III., No. 1.

*Journal of the Natural History and Science Society of Western Australia.*

Year.	Vol. No.	Date of Publication.
1910	III., No. 1	Between 1st and 14th June, 1910.
1911	III., No. 2	Between 12th September and 10th October, 1911.
1912	IV. ....	Between 1st and 11th February, 1913.
1914	V. ....	1st or 2nd March, 1915.

Royal assent having been granted, the name of the Society was again changed on 10th March, 1914, to that of "The Royal Society of Western Australia." Publication was continued under this name, the first issue of the Journal being numbered Volume I.



*Journal of the Royal Society of Western Australia.*

Year.	Vol. No.	Date of Publication.
1914-15	I.	Between 12th October and 14th November, 1916.
1915-16	II.	Probably between 10th and 31st July, 1917 ; definitely between 10th July and 20th August, 1917.
1916-17	III.	Between 8th October and 10th December, 1918.
1917-18	IV.	Between 8th April and 12th May, 1919.
1918-19	V.	Probably March, 1920.
1919-20	VI., Part 1	Between 7th April and 13th July, 1920.
	VI., Part 2	Between January and March, 1921.
1920-21	VII.	Between July and December, 1921.
1921-22	VIII.	21st December, 1922.
1922-23	IX., Part 1 ...	26th April, 1923.
	IX., Part 2	4th January, 1924.
1923-24	X.	25th November, 1924.
1924-25	XI.	Between 6th November and 2nd December, 1925 : probably 16th November, 1925.
1925-26	XII.	Between 25th May and 12th July, 1927.
1926-27	XIII.	Between 4th May and 5th June, 1928.
1927-28	XIV.	Between 3rd May and 7th June, 1929.
1928-29	XV.	Between 7th March and 6th June, 1930.
1929-30	XVI.	13th October, 1930.
1930-31	XVII.	Between 27th August and 13th October, 1931.
1931-32	XVIII.	Between 26th May and 13th June, 1933.
1932-33	XIX.	30th May, 1934.
1933-34	XX.	11th December, 1934.
1934-35	XXI.	Between 23rd December, 1935, and 25th February, 1936.
1935-36	XXII.	Between 16th October, and 6th November, 1936.
1936-37	XXIII.	25th January, 1938.
1937-38	XXIV.	Between 11th October, and 16th November, 1938.
1938-39	XXV.	20th March, 1940.
1939-40	XXVI.	Between 30th May and 20th June, 1941.
1940-41	XXVII.	10th June, 1943.
1941-42	XXVIII.	22nd May, 1944.

*Publications of the Mueller Botanic Society of Western Australia.*

(Journ. W.A. Nat. Hist. Soc., 1906, III., 4).

No.	Date.
1	September, 1899.
2	October, 1899.
3	November, 1899.
4	December, 1899.
5	January, 1900.
6	May, 1900.
7	September, 1900.
8	December, 1900.
9	January, 1902.
10	December, 1902.
11	April, 1903.

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